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SANITARY SUGGESTIONS OR THE HOUSEHOLDERS VADE MECUM

BY

SAMPSON LOW JUN

B.A. CANTAB. &c.

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DEFECTIVE DRAINAGE, VENTILATION, &c.,

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SANITARY SUGGESTIONS;

OR, THE

HOUSEHOLDER'S VADE MECUM.

BY

SAMPSON LOW, JUN.,

B.A. CANTAB., ETC.

London:

SAMPSON LOW, MARSTON, SEARLE, & RIVINGTON,

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*** The Author desires to record his indebtedness to the undermentioned gentlemen for their courtesy in forwarding to him, specially for insertion in this book, illustrations of their appliances :—

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To Messrs. Capper, for figs. 19, 20.
To Mr. Thomas Twyford, for figs. 7, 21, 22, 23.
To Messrs. Comyn Ching, for figs. 29, 30, 31.

PREFACE.

AFTER perusing works on the subject of Drainage and Ventilation a common remark of engineers, architects, and others is that nothing new has been elucidated. My aim in this pamphlet is not to instruct sanitarians, but to follow step by step the progress of sanitation during the last decade.

Many attempts have been made of late years to induce the general public to interest themselves in these subjects, but the present time seems to me peculiarly appropriate for offering a few practical suggestions to householders, it being my belief that much sickness and suffering may be prevented, by acquiring a knowledge of the bases of hygienic laws as applied to our own homes. During the latter part of an unusually hot summer we have been threatened with a cholera epidemic, and most authorities acknowledge that this terrible scourge will in all probability visit our shores in the course of the next three years. If the following remarks induce some of my readers to "set their houses in order," so as to minimize the chances of infection when the danger is really with us, the object of this little work will be accomplished.

In conclusion, I beg to thank the numerous gentlemen and firms of sanitary engineers for the kind and considerate way in which they have put their practical knowledge at my disposal.

October, 1884.

LIST OF ILLUSTRATIONS.

		PAGE
Fig. 1.	The Old System	8
2.	The Intermittent	13
3.	Dip-trap	15
4.	"Intermittent" (ventilation of soil-pipe only)	19
5.	Banner's closet	22
6.	" " Section	23
7.	"S" trap	24
8.	"P" trap	24
9.	Cap and screw trap	24
10.	Disconnecting trap	28
11.	The "Continuous"	30
12.	"Bent junction"	32
13.	Wiped joint	33
14.	Grease-trap	34
15.	Downcast ventilator	35
16.	Upcast "	36
17.	Downcast "	36
18.	Upcast "	36
19.	Messrs. Capper's closet	37
20.	" " "Twin-basin" closet	38
21.	The National closet	59
22.	The Alliance "	59
23.	The Crown "	60
24.	Trap experiment	61
25.	Hermes'-Crown air-inlet	87
26.	" " Section	87
27.	Inlet bracket	88
28.	Louvre ventilator	88
29.	Circular ventilator	88
30.	Mica flap ventilator	89
31.	" " Section	89
32.	Ornamental exhaust ventilator	90
33.	" " "	90
34.	"Anti-rebound" cowl	95
35.	"Cavendish" cowl	96
36.	"Crown ejector" cowl	96
37.	"Cambridge" cowl	99

SANITARY SUGGESTIONS.

INTRODUCTORY.

THE study of the subject of Sanitation has made remarkable progress in the last few years, and certainly our late International Health Exhibition has done much, very much, to awaken the public to a sense of the great danger to which it has hitherto exposed itself. But apart from real advance in sanitation there is evidence of an unreal and unsatisfactory outcome of the recent movement, viz.: an unhealthy sanitary craze,—the product and result of a teaching which has been "over the heads" of the people, and which they have not understood. I fear indeed that we may as yet look in vain for any assurance that the sanitary enthusiasm aroused by the South Kensington Temple of Hygïeia and its high priests will not in a short time give place to a reaction which will be far worse than the original torpor. The teaching that is now required to prevent the misfortune is such as in the first place will commend itself by its simplicity and clearness to the ordinary understanding, and in the next place such as will not engender mistrust. For no great point will be gained until the people understand that sanitation is the science of the household, and is no "mystery" revealed exclusively to, and for the particular benefit of so-called "Sanitary experts," and "Associations," "Companies," and so forth.

We have been told over and over again, that "recent discoveries have proved the old modes of dealing with house sanitation to be entirely wrong, and that there is even now scarcely one house in a thousand which is not a source of danger, not

only to its own inmates, but to those on the adjoining premises as well." It is, too, an open secret that many very serious diseases owing their origin to zymotic causes, such as typhoid fever, diphtheria, and the like, are due to sewer gas in some shape or form coming in contact with our internal organism, yet, in spite of all these warnings from those who should know, I think I am not far wrong in saying that practically nothing has been done to show the public exactly whence these dangers arise, and where and how they may be met.

I shall in the following pages set forth what seem to me to be the most glaring sources of danger, and shall then do my best to indicate what I hold to be the easiest means of combatting and overcoming those causes of evil.

Let it be clearly understood that, in all the faults I endeavour to point out, I deal only with faults of design, not wilful faults of construction. Did I attempt the exposure of the latter class of faults, I fear that this *brochure* would assume most alarming proportions, as there is hardly a piece of sanitary work which is not capable of being "scamped" with (as far as the "scamper" is concerned at least) great and immediate success. The great safeguard of the general public must be, I think, the mastery of the subject for themselves, so that they may be almost as competent of judging where evils are liable to arise as any of the aforesaid sanitary experts.

I propose asking you to consider with me a few of the conditions which tend to make us as a nation, and each, as an individual, 1st, healthy, 2nd, comfortable, and 3rd, content. I have arranged the matters which I wish to bring before your notice in what I consider to be an "order of decreasing magnitude of importance," therefore I must first draw your attention to the paramount condition, viz., "that every inhabited building shall be drained under an efficient and reliable system." And in order that we may arrive most surely at such a system we will, step by step, understand thoroughly "the why and the wherefore" of every sanitary appliance, be it "trap," closet, bath, or even pipe, in our houses.

I take it, an efficient system of house sanitation seeks (1) to cut off all communication between the public sewer and the house; not, be it understood, "between the house and the sewer;" (2) to keep the air which is in the house drain and soil pipes themselves in a state of rapid motion—or in other words, to surround the house with a belt of rapidly-moving air; and (3) to prevent all noxious gases from entering the house.

I hope, with the aid of some diagrams, I shall be able to show you the errors which now unhappily are so common. First, I shall deal with the *old* (alas! not yet sufficiently consigned to the age of the "past") system of house drainage; then I shall point out what has been going on in the way of "reform" in the policy of sanitation; and finally, I shall endeavour to show you what I think I may justly term the ultimate state of perfection to which reform and research have up to the present brought us. Far be it from me to say there is no room for improvement;—there is very great room, but still I think it the duty of any one writing for what he believes to be the public welfare, to indicate clearly what he considers to be the best system of sanitation yet obtained. Before plunging at once *in medias res*, it might be as well if we took a cursory glance at the advancement which sanitation has made up o the present. For this purpose the following may be taken as a brief historical sketch of the various systems of house sanitation.

Fifteen or twenty years ago no one thought very much about drainage or "health in the house," or at all events, if he did he kept it to himself; but we were awaked from our repose one day by the alarming intelligence that the life of no less a personage than the Heir Apparent was in hourly danger. In a word the Prince of Wales was struck down by a malignant attack of the dread typhoid (gastric) fever which doubtless owed its origin to one or all of the many faults existing in the "then" system of house drainage.

Up to that period, I think I may say without much fear of

contradiction, that the only so-called system of house drainage in vogue was the one to which I shall hereafter allude as "System I.," or the "Old System."

The startling occurrence to which I have above made reference, which, so to speak, shook the whole nation to its very foundation, created a feeling of insecurity in the minds of all, and set the medico-sanitary world thinking how best to defend us from the evil effects arising from faulty systems of house sanitation. The result of all this cogitation was, I believe, the evolution of the Intermittent system of sanitation, which under many aspects and with many modifications, has been in vogue until the last year or so amongst most of us who cared at all for the cry of "healthy homes." This system I shall subsequently allude to as System II., or the "Reformed," or "Intermittent."

Still more recently there has been a new departure in the policy of sanitation. This is most certainly a step in the right direction; by it not only is our soil pipe kept pure, but moreover, our house drain is rendered sweet and clean, and sewer gas, even if it should "force" the disconnecting trap, is excluded from the precincts of either the house drain or the soil pipe (i.e. that pipe into which our closets lead), by being immediately sucked up a vent pipe (or exhaust shaft), which is situated *between the house and the disconnecting trap*. These are great advantages which amongst others will be apparent to one studying the diagrams shown subsequently. In this system there is always a current of air rushing *down* the soil pipe to the main drain *towards* the sewer. This system I shall allude to as the "The Continuous."

I shall endeavour to compare *seriatim* the main points of difference in construction—condemning the faults and approving the corrections thereof—existing in the three systems of house sanitation.

As far as possible (that is to say, where identic appliances occur in the three systems), I shall number in small figures each paragraph, so that my readers can easily refer from one

system to the other, and see for themselves where the improvements are, and in what they consist. In many instances of detail no very great difference will be observed between II. and III., the "Intermittent" and the "Continuous."

Wherever practicable, I shall introduce diagrams, as I know from experience, that nothing tends so much to facilitate comprehension as their presence.

The headings of the various systems will be as under, in large figures:—

I. The Old.

II. The first reformed, or "Intermittent."

III. The second reformed, or "Continuous."

After the consideration of each system has been gone into *seriatim* I shall append a brief epitome of comparison between the three, pointing out the relative merits of each.

I propose to start my consideration of each system, from the point where the house system proper commences (or to speak perhaps more correctly, "ends"), namely, at a point where a "trap" of some kind is inserted to disconnect the house drain from the public sewer or the cesspool. As the ordinary householder has probably never heard of the construction and use of these sanitary appliances, it may perhaps be as well to state shortly, and clearly, what these "disconnecting traps" are, and what they are intended to do. Such a trap is a contrivance constructed with the idea of allowing matter to pass through it in only one direction (i.e. from house drain to sewer or cesspool), but I think it is tolerably obvious that the passage of matter is pretty certain to allow of the "reflux" of air under pressure (i.e. passage of sewer gas from the sewer to the house drain).

SYSTEM I.

1. The Disconnecting Trap.

In the worst forms of the Old system of drainage the disconnecting trap between the sewer and house drain was often omitted, or, if a trap was provided, it was not infrequently made

with bricks and mortar, or cement, liable to leak, and with no inspection cover for cleaning purposes, so in the event of a stoppage it had to be broken open. With regard to its position, it was often covered in, so that if strange workmen were employed they had to break up unnecessary ground in order to find it. Again, the shape of traps formerly in use, notably the Mason's trap, made it impossible for them to clear themselves from deposit. In addition to this, they frequently became unsyphoned, which rendered them quite useless.

2. The House Drain.

Leaving the trap, and passing on towards the house, we next come to the house drain. If this is made of brick, whether it be inside the house or outside, the difficulty of making it water-tight is so great, that leakage is almost certain to take place, and find its way beneath the basement of the house; and, where wells are used, percolate through the ground and contaminate the drinking-water.

In making alterations, the safest plan is to arrange the house drain in such a position that the slightest leak will be at once perceptible. The best place for it is along a wall either outside or inside the house. Engineers differ in opinion as to whether the house drain should be made of iron pipes, or glazed drain pipes,—also as to the kind of joints to be used; but all will agree that the first object in view is to have the drain air-tight and water-tight, and that any arrangement which enables a flaw to be easily detected is good. A warning which is often disregarded, and which almost invariably shows mischief where sewer drainage exists, is the appearance of rats in the basement of a house. Sewers are full of these useful little scavengers, and where a drain has become imperfect, they will venture through the disconnecting trap, and, by their presence in the house, announce the fact that the drain is out of order.

In addition to these defects, the shape of brick drains is often rectangular, and the foundations defective.

3. Appendages of the House Drain.

(*a*) Ventilation pipes.—Under the old system no ventilation of the house drain was attempted. I shall show further on, that both inlet and outlet ventilation pipes are absolutely necessary.

(*b*) The soil pipe, viz. that pipe into which the closets lead, was put inside the house, and was often made of earthenware pipes, badly jointed, and too large to be properly cleaned when the closets were flushed (i.e. put in action). If lead pipe was used, it was often so light that it soon became "holed," thus allowing drain gas to enter the house. The connections were made with blow-pipe joints instead of with plumbers' joints, and the whole arrangement of pipes was so hidden away as to be difficult to get at.

(*c*) The grease trap.—No grease trap (i.e. an interceptor for receiving grease and preventing its passage into the drain) was provided for the sinks.

(*d*) The splash pit.—No splash pit was provided for waste from baths, rain water from roof, &c.

4. Ventilators.

Such appliances were either unknown or ignored.

5. Closets.

The ordinary form, known as the pan closet, was mostly in use, with a large metal container, which soon became foul, and could only be examined by aid of a workman. Beneath this closet (as shown in fig. 1) was a fixed trap, which merely served as a receptacle for filth, and, worse still, checked the flow of water passed through the closet, thus preventing it attaining sufficient velocity to cleanse the pipe. The supply to the closet was delivered through a pipe of half, or at most three-quarter, inch diameter, and was totally inadequate for the purpose. The waste from the closet safe delivered either into the closet trap, or had a trap of its own, which was sup-

posed to disconnect it from the soil pipe; but instead of doing so, it soon became dry, allowing a free passage for drain gas.

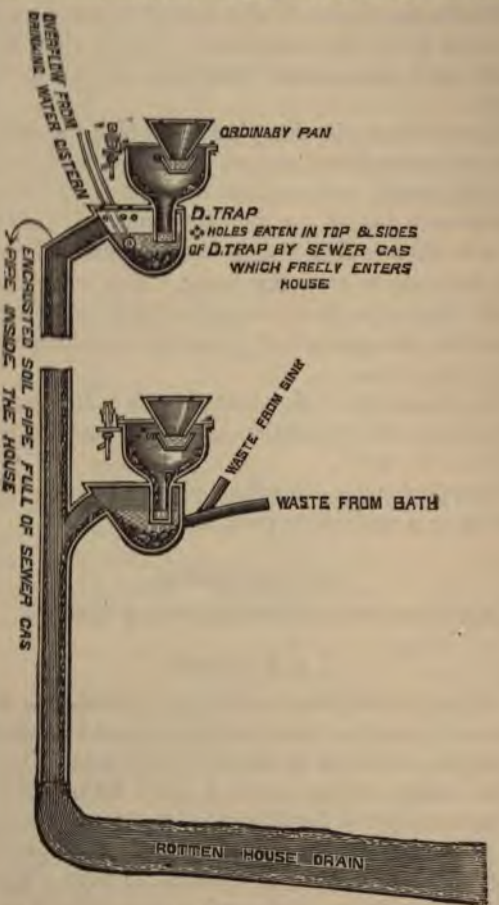

OVERFLOW FROM DRINKING WATER CISTERN
ORDINARY PAN
D. TRAP
HOLES EATEN IN TOP & SIDES OF D. TRAP BY SEWER GAS WHICH FREELY ENTERS HOUSE
INCRUSTED SOIL PIPE FULL OF SEWER GAS
PIPE INSIDE THE HOUSE
WASTE FROM SINK
WASTE FROM BATH
ROTTEN HOUSE DRAIN

Fig. 1.

Finally the closet seat was screwed down, instead of being hinged for easy inspection.

6. Closet Traps.

The most common form of trap in use was the D trap (fig. 1), made of lead; a contrivance which has been justly described as "a plumber's device to largely increase the labour and material employed in sanitary work." This trap was intended to prevent noxious exhalations passing into the house from the drain, where, if ventilation had been provided, no smells could have existed. Its usefulness, even for the purpose for which it was intended, is fitly described in a letter which appeared in the *Morning Post* of October 6, 1884:—

"*Sanitary Arrangements.*

"To the Editor of the *Morning Post.*

"'Some one has blundered.'

"Sir,—We have read with great interest, in your issue of to-day, the able article on 'Sanitary Shortcomings,' and, if we may be allowed, we would like to call attention to one or two points on which we frequently find 'some one has blundered.' Briefly, they are—

"1. Placing too much reliance on closet-traps in the house as a 'seal' against sewer gas. Now it should be clearly understood that sewer gas is soluble in water, and thus there is always (in unventilated systems of house drainage) a solution of sewer gas standing in the house; and, again, when the water in the trap has become impregnated with this gas to 'saturation point,' the gas forces this 'water seal,' and finds easy entrance into the house." . . .

Another fatal objection to the D trap was, that in houses of several storeys, the effect of emptying the top closet was to syphon out (i.e. to empty) the trap of the closet below.

7. Wastes.

(*a.*) Sink Wastes.—These pipes were either trapped into the drain, or discharged into the trap of the nearest closet. Now, as the waste products from sinks always consist of in-

gredients more or less greasy, which, if allowed to enter the drain, adhere to the sides, and, in conjunction with other matter, soon cause a stoppage, this will at once be seen to be a very grave blunder. Where the pipes discharged into the closet trap, things were even worse, as their contents having been congealed by contact with cold matter, found further obstructions in the angles and projections of the trap. Again, if water in which greens had been recently boiled (a frequent waste product of the culinary departments) was thrown down such a sink, an unpleasant smell permeated the whole house. The traps, moreover, being then filled with hot water, acted as aspirators, and drew vitiated air from the drain into the house. In the writer's experience, this has been a most fertile source of mischief, the insidious ingress of sewer gas being disguised by the stronger effluvium.

(*b.*) BATH WASTES.—These pipes delivered into the soil pipe or D trap of nearest closet. This would again be a very frequent cause of danger, as the pipes, leading from the bath or lavatory, which is situated in the interior of the house, serve to conduct thither the noxious emanations, which are the result of decomposition going on in the drain;—the passage of these gaseous particles being facilitated by the *vis-a-tergo* (the high pressure at which the gas is generated in the drain), and also by the *vis-a-fronte* (the suction power exerted by the warm house). So recently as July last, the author's attention was called to a patient whose case presented unmistakable symptoms of what is popularly known as "blood-poisoning." On careful inquiry being made, it was found that the patient had been in the habit of using a certain lavatory, and that she had frequently remarked the unpleasant effluvium arising therefrom, especially when hot water was used. Further investigation into the cause of her illness resulted in the discovery that the waste and overflow pipes from the lavatory in question, discharged into a neighbouring closet trap! I mention this fact—not, I believe, an isolated one—as coming under my direct notice.

8. Cisterns.

Among the numerous bad positions in which cisterns were fixed in the Old system, I may mention the following:—over closets,—or under closets on upper floors. The former position bad, as noxious gases rising from the closet were arrested in their ascent and taken up by the water; the latter equally bad, as leakage or overflow from the closet above often found its way into the cistern beneath. To make matters, if possible, worse, the overflows from the cisterns were led into the soil pipe or else into the D trap of the nearest closet, or into a rain-water pipe, which was often used as a soil pipe. Any of the above arrangements led to contamination of the water in the cistern, an evil more insidious in its ultimate result than almost any other sanitary blunder, being a most frequent cause of febrile disease; for the gas, after having traversed the overflow pipe in the direction of the cistern, passed over the cold surface of the water in the cistern beneath, and thus having its temperature lowered, fell and was absorbed by the water, forming a "solution of sewer gas," the ultimate destination of which was probably the digestive tract of the inmates of the house.

9. Rain-water Pipes.

It is not an uncommon thing to find the lower parts of rain-water pipes used as soil pipes; a very obvious blunder, as the open head of the pipe is necessarily so low that any gas arising from it is likely to be drawn into the house.

10. Urinals.

These most objectionable contrivances require frequent cleansing, and should therefore be as free from angles as possible. They should be entirely dispensed with in houses, if such a course is practicable.

SYSTEM II.—THE "INTERMITTENT."

THE idea of ventilating house drains originated, I think, in this country, about the year 1850, but the movement was then in its infancy, and very crude notions were set forth; the following quotation from Mr. Baldwin Latham's "Sanitary Engineering," 1878, gives a fair notion of the date of the introduction of house-drain ventilation on the intermittent system.

"During the last three or four years, various suggestions "have been made in order to render more perfect the system "of house-drain ventilation, and it is now generally thought "that openings should be provided both for the entrance of "air into the house drains, at one point, and provision should "be made for its extraction at another point." A system similar to fig. 2, was patented in 1875.

The model bye-laws issued by the Local Government Board require the ventilation of house drains to be effected by means of "two untrapped openings," as will be seen from the following paragraphs culled from "Knight's Model Bye-laws."

"Every person who shall erect a new building shall, for the "purpose of securing efficient ventilation of the drains of such "building, comply with the following requirements. He shall "provide two untrapped openings, and, in the provision of such "openings, he shall adopt such of the two arrangements 'a' or 'b' "hereinafter specified, as the circumstances of the case may render "the more suitable and effectual."

Either

(*a*) "One opening being near, or at, the level of the ground, "shall communicate with the drains by means of a suitable pipe, "and shall be situated as near as may be practicable to the trap "(disconnecting-trap), which shall be provided between the drain "of the building and the sewer. Such opening shall also in every "case be situated on that side of the trap which is nearer to the "building.

(i.e. in the position of the inlet in fig. 2.)

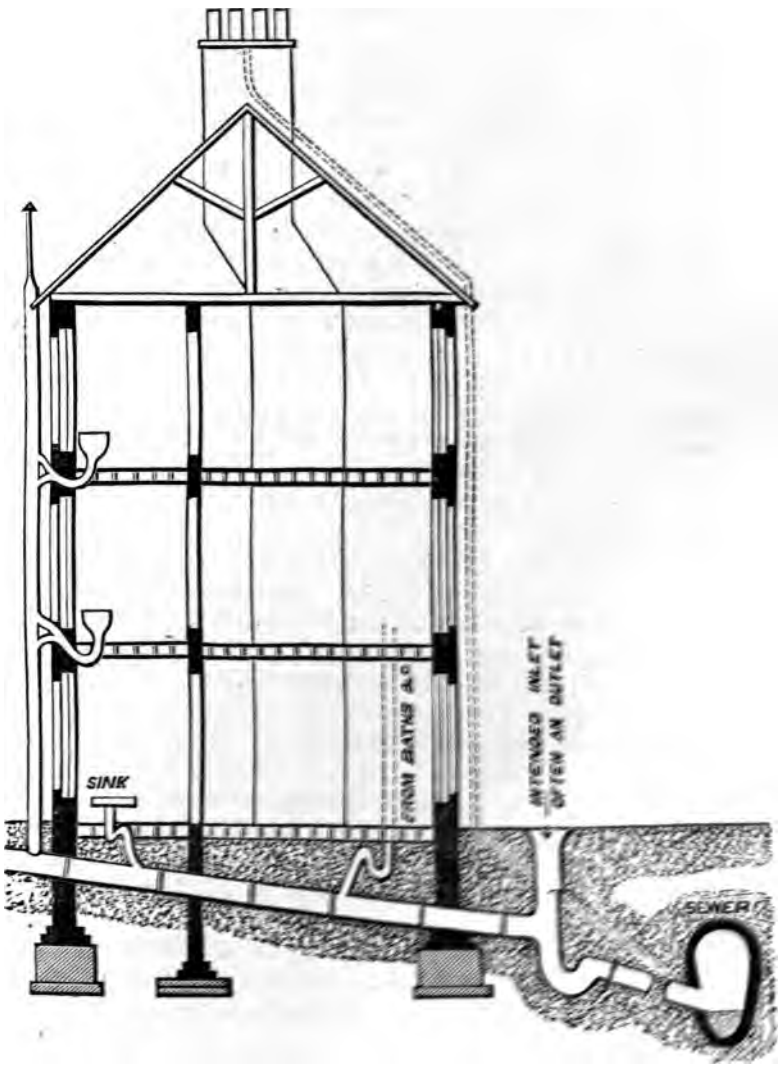


Fig. 2.

"The other opening shall be obtained by carrying up from a "point in the drains (as far distant as may be practicable from the "point at which the first mentioned [inlet] opening shall be situated), "a pipe or shaft vertically to such a height *and in such a manner* "(my italics), as effectually to preclude any escape of foul air "into any building in the vicinity."

Or (*b*)[1] * * * * * *

NOTE.—If the soil pipe be used as this second "pipe or shaft" (which is permissible—see par. V., Knight, p. 98, provided it is utilized "*in such a manner*" as to be harmless to neighbouring buildings), we have the origin of the Intermittent system; but from the following considerations it will be tolerably obvious that the soil pipe cannot be so used with impunity: there is only a current *up* the soil pipe when matter is *not* passing down it; but when matter is passing down it, the would-be inlet becomes the outlet, and if foul air were projected from that opening—see fig. 2—it could not but be harmful, not only to neighbouring buildings, but also to the very house itself.

For my own part, I think the idea of making the soil pipe the upcast ventilating pipe (or foul air exit pipe), which is the case in all modifications of this "Intermittent" system, is undesirable for many reasons, one of which I will mention, as it is quoted by no less an authority than Mr. Baldwin Latham. He says, "The fall of water down a soil pipe will reverse any air current, even when set up by the most powerful extracting cowl that can be devised;" and again a firm of sanitary engineers, who, seeing the danger besetting the intermittent system, adopt means to nullify its results, as will be seen from the following remarks:—"An air *inlet* to a drain becoming, under certain conditions, an *outlet* for vitiated air. . . ." "We are of opinion that it may be so, caused either by the drain being charged with water, and thus displacing air, which finds egress at the aperture intended for the inlet; or by a defect in the upcast shaft, admitting cold air, and causing a reversal of the

[1] The second, and, I consider, better suggestion of the Local Government Board, I shall discuss under System III.

current. . . ." "We suggest that the inlet should *always be fixed* at *some distance from any doors* or windows, and at a point where, should a reversal of current take place, no danger would occur." . . . "We show the *inlet* carried to the roof" (Broad and Co.). Moreover, I would suggest that a reversal of the normal current takes place when matter passes down the soil pipe (i.e. *every time* the closets are put in action), and again, supposing all goes as the designers of this system wish, is it desirable to have the pipe, into which our closets lead, performing the function of "scavenger" for the whole length of our house drain, which is the case, under this *régime*, unless the house drain and soil pipe are ventilated independently of one another: and this entails considerable additional expense. I think it is a very questionable policy to cause the noxious exhalations, which are sure to arise from decomposing matter, to pass in such close proximity to the closets.

So much then for the main principles of the "intermittent" system; let us now inquire into its special sanitary appliances.

1. The Disconnecting Trap.

The vast improvement in the construction of this sanitary appliance may be accounted for by the fact that men of education begin to recognize the importance of providing an efficient barrier between the sewer, or cesspool, and the house drain, and also the necessity of ventilating the house drain and soil pipe independently. The leading features of all these traps are the same, although their forms are numerous.

Fig. 3. Dip-trap.

A simple bend in the pipe is the most common, supplemented by a "dip-trap" at the foot of the soil pipe (for diagram of dip-trap see fig. 3). This latter appliance I

unnecessary, and I think I may go further and say wrong, and in this I am upheld by the Model Bye-laws of the Local Government Board. In support of my view I append the following extract from "Knight's Annotated Bye-laws:"—

"A person who shall erect a new building. . ." He shall so construct such soil pipe, that there shall not be any trap between such soil pipe and the drains" (i.e. house drains), "or any trap (other than such as may necessarily form part of the apparatus of any water closet) in any part of such soil pipe. NOTE.—The provisions of the third paragraph" (the one quoted above) "are desirable, in order to avoid a useless impediment in the passage of sewage, from the soil pipe to the drain." (Knight, pp. 101, 102.)

2. THE HOUSE DRAIN. (Fig. 2.)

The numerous modifications of the "intermittent" system render it very difficult for me to say what special material of pipe is used, as there is a considerable divergence of opinion on this point. I may mention, as having come under my direct notice, glazed stoneware, with either asphalte or cement joints; concrete, cemented inside with cement joints; and cast-iron pipes coated with tar, and jointed with lead.

In the selection of the material, the desiderata are—durability, small frictional resistance, capability of resisting action of contained matter, and emphatically NOT CHEAPNESS.

3. APPENDAGES OF HOUSE DRAIN.

In this system of house-drain ventilation the first "appendage of the house drain" to which we come is the inlet ventilating pipe. (Fig. 2.) It is situated between the "disconnecting trap" and the house, in positions of varying proximity to the latter; if in very close proximity, and if the designer is careful, it is carried to some point clear of the roof, but it is no uncommon thing to see in various plans of house drainage this inlet consisting merely of a short pipe carried from the house drain at a point close to the "disconnecting trap" to just above the ground level, and sometimes ending in an open grating. (See fig. 2.)

This, in theory, is doubtless all right, but, as we have seen

above, during the passage of water or other matter from the closets, down the soil pipe (here the upcast pipe) air is propelled before this body of water and also sucked after it, and consequently the normal current is reversed, and this "inlet" becomes a temporary outlet, with a result which perhaps can be imagined better than described.

The explanation of this system may perhaps be found in the fact that some sanitary engineers, who are also manufacturers and proprietors of patent cowls, have such a belief in their own "exhaust" ventilators that they lose sight of the fact that however excellent any cowl may be, its only function is to accelerate natural currents, and not to reverse them, and they do not admit that it is possible for air to go down any shaft on which one of their patent contrivances is fixed. Fact does not bear out these theories.

The second "appendage" is the soil pipe.

Materials which, even to this day, are commonly used for the soil pipe are:—

(*a*) "Salt glazed" earthenware pipes:—these are unfitted for this purpose, owing to their liability to fracture at the joints, or to crack owing to "settling" of the house, and other causes; notably from being "rammed home" into the house drain.

(*b*) Zinc soil pipes are occasionally used, for the sake of cheapness, but, like most cheap things, they are very undesirable; this metal is unable to withstand the action of moist sewage and vapour-impregnated sewer air.

(*c*) Wrought iron;—similar objections.

(*d*) Cast iron;—this form of the metal which consists of iron with small particles of carbon and silicon has been tried for soil pipes, but though preferable to wrought iron, its use is not to be commended. The properties and appearance of different specimens of cast iron vary according as one specimen contains more or less carbon and silicon than another, for cast iron is not, it must be borne in mind, a definite chemical compound of the pure metal (iron) with carbon and silicon.

Cast iron is classed in order of increasing carbonization,

as "4," "3," "2," or "1," according to the amount of carbon admixed. This varies from 2 to 4 per cent., "1" being the most highly carbonized.

Sometimes sulphur and phosphorus are found in specimens of cast iron; these are undoubtedly impurities—the former constituting a form known as "red short;" whilst the term "cold short" is given to the latter. Arsenic may be mentioned as a desirable admixture; it is, at all events, supposed to improve cast iron for working purposes; though the chemist would stigmatize its presence as an impurity.

(*e*) Lead is unquestionably the best material that can be used, but it depends very much on how "fine" the sanitary contract is "cut" whether the use of lead soil pipes shall be a success or not. Good lead and good work cost money!

Next, let us consider the position of the soil pipe. I am glad to say I have not come across one plan of this system in which the soil pipe was situated in the interior of the house. As to the size desirable there seems to be some divergence of opinion. I do not think a pipe of less diameter than 4 inches should be used, except for very small houses.

Frequently the soil pipe is contracted above its junction with the pipe from highest closet, terminating in a 3-inch or $2\frac{1}{2}$-inch, and sometimes even in a 2-inch ventilating pipe, with exhaust ventilator affixed. (See fig. 4.) This constriction at the top of the pipe is wrong. The "Bye-laws" direct that the pipe shall be "continued up without diminution of its diameter." A full explanation of this apparently arbitrary rule will be found, I think, in the following:—

We have a soil pipe of 4 inches diameter, and the sectional area ($=D^2 \times \cdot 7854$) of a 4-inch pipe is 12·56; for

$$D^2 \times 7854 = 16 \times \cdot 7854 = 12 \cdot 56 \ . \ . \ .$$

and if we constrict this 4-inch diameter pipe to $2\frac{1}{2}$ inches, we get a constricted area of

$$(4)^2 \times \cdot 7854 : (2\tfrac{1}{2})^2 \times \cdot 7854;$$

or,

"as $12 \cdot 56 : (\frac{25}{4} \times \cdot 7854) =$ as $12 \cdot 56 : 4 \cdot 90$,"

that little $1\frac{1}{2}$ difference in the diameter of the pipe expands to alarming proportions when treated in terms of sectional area!

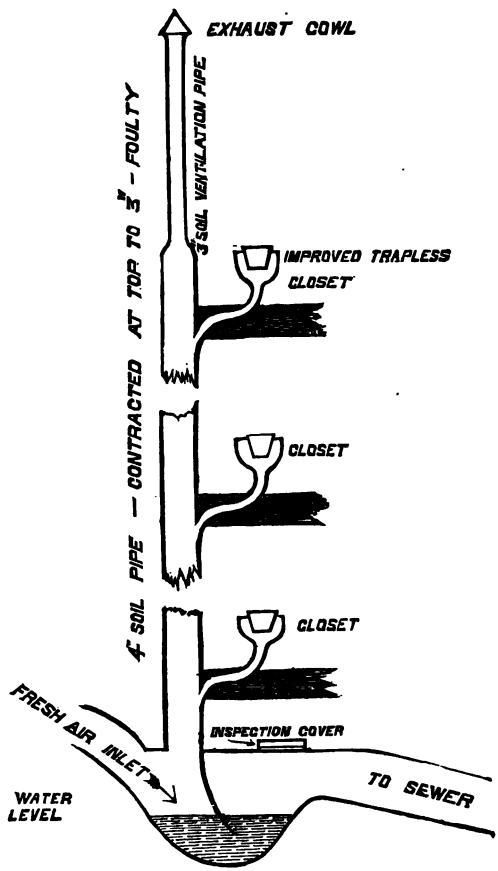


Fig. 4.

But perhaps my readers may say, "Ah, but then in these cases there is a ventilator on the $2\frac{1}{2}$-inch pipe, and that always

makes a difference." I beg their pardon; it does not! except to the manufacturer of the instrument in question. There are cases when "ventilators" are necessary; and there are also cases where they do little or no good. Again, there are exhaust ventilators, too, which, so far from accelerating the up-current, actually obstruct the free passage of air. Imagine one of these fixed on a vent pipe of "constricted area."

There is one other modification of this intermittent system to which I will make a passing reference. The house-drain is provided with special ventilating pipes, and the soil pipe is ventilated independently. Moreover, the soil pipe, in this instance, is often the common duct for refuse from closets, baths, sinks, &c., &c. At the foot of the soil pipe there is a dip-trap, which empties into the house drain. This is a very undesirable arrangement of pipes, and I should never recommend its adoption. I question if any sanitary authority would sanction such a scheme of drainage. Let us see what the Local Government Bye-laws have to say on the subject (for dip-trap; see ante, p. 15).

"He shall also cause the waste pipe from every bath, sink (not being a slop sink, constructed or adapted to be used for receiving any solid or liquid filth), or lavatory, the overflow pipe from any cistern and from every safe under any bath or water closet, and every pipe in such building for carrying off waste water, to be taken through an external wall, and to discharge in the open air *over a channel leading to a trapped gully grating at least* 18 *inches distant.*"

"He shall, as regards the mode of construction of the waste pipe from any slop sink, constructed or adapted to be used for receiving within such building any solid or liquid filth, comply in all respects with such of the provisions of this bye-law as are applicable to the soil pipe from a water closet."

"NOTE.—The requirements of the fourth paragraph relate to waste pipes and the like, and are important as securing the necessary break in the continuity of air in the waste pipe and drain. It is always to be remembered that gulleys, even above the water trap in them, tend to become foul, and waste pipes soon become coated on the inside with offensive matter.

"The slop sink referred to in the fifth paragraph relates only to such sinks as are commonly used in hospitals and elsewhere, and which, since they receive *excreta*, should in point of construction be dealt with as water-closets." (Knight, pp. 102, 103.)

(*c*) *The grease trap.*—This contrivance has various positions assigned to it. Into it deliver wastes from baths and sinks; that is to say, it is constituted a common receptacle for the refuse from baths, housemaid's sink, and scullery sink. There are many objections to this plan, not least of which is inaccessibility for cleaning purposes.

(*d*) *Splash pit.*—This apparatus consists of a small gully, which receives (in this system) the discharge from the rain-water pipe. It is usually connected, by means of a pipe with a bend in it, with the house drain.

4. Ventilators.

Usually only one ventilator, an exhaust, is used. It is fixed on the soil pipe, and is supposed to insure the passage of foul air up the soil pipe; but, as we have seen, the direction of this current depends on many circumstances, besides the efficiency of the ventilator; it is admitted that no ventilator can always insure an up current in the soil pipe. [Sometimes a down-draught cowl is also used on the inlet pipe when this is carried to the roof of the house.]

5. Closets.

The most common forms in use are wash-out closets, valve closets, and pan closets. Wash-out closets consist of pans, containing a very small amount of water, with traps below them. The water used for flushing is generally delivered from a small tank (water-waste-preventing cistern), and the supply is limited to two gallons, which is seldom sufficient to cleanse the pan and "trap." To be really efficient such closets should be flushed from a syphon tank, delivering at least three gallons through a 1¼ or 1½ pipe, according as the fall is great, or the reverse. For specimens of

these closets see diagrams 21, 22, 23. Valve closets, as their name implies, have a close-fitting valve at the lower end of the pan, which is opened and shut by elevating or depressing the plug-handle of the closet. When of the best construction they retain about a gallon of water in the pan, which in itself is a good thing, and affords sufficient disconnection between the soil pipe and closet, without the addition of a trap if the soil pipe is adequately ventilated.

For a good pattern of this closet see diagram 19, page 37.

Pan closets, of the old pattern, with large metal receptacles hidden away under the closet seat, are most objectionable, as they so soon become foul.

A very good pan-closet is Mr. Banner's patent (fig. 5), which it will be as well to describe here:—

BANNER'S PATENT WATER-CLOSET.

Fig. 5.

This apparatus is constructed in parts so arranged that any person can readily take apart, cleanse, and replace the whole.

The receiver is made in one piece of white earthenware, with inlet for water and flushing rim. Below this rim is a channel, for containing water, and the basin is made with

a turnover rim at top to dip into this channel, which forms a hermetically sealed joint; at the same time the basin can be easily removed, which is a ***distinctive feature*** in this invention.

The Saucer is also of earthenware, and is fitted on a metal bush which fits into a slot in the axle.

The axle, being short, is not liable to get broken, as is the case in other closets.

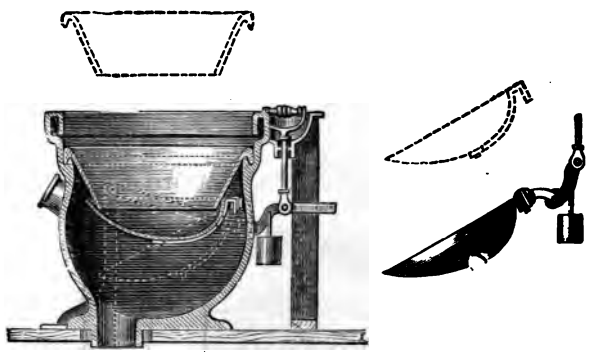


Fig. 6.

SECTION AND MOVABLE PARTS OF BANNER'S PATENT WATER-CLOSET.

The dotted lines indicate the position the Saucer assumes when the handle is raised, so as to discharge the contents of the Saucer through the outlet.

The whole of the apparatus may be thoroughly ventilated by an outlet arm as shown in above figure.

6. Traps.

In the various modifications of this system, traps under the closets are used or not at discretion; but I think there is no necessity for them. I am glad to say I have not seen the old "D" trap associated with this system once; the angles and projections of this most unseemly contrivance

simply serve to retain all manner of filth, which cannot but be prejudicial to health. Often, indeed, what is popularly known as "the drains smelling," is caused by the emanations from the accumulation of filth in this D trap (See fig. 1, page 8.)

Traps in any shape or form must necessarily hinder the rapid passage of matter from the closet to the soil pipe.

Fig. 7.

Some forms of traps known as "S" traps and "P" traps are perhaps less objectionable, but they are one and all the outcome of the old "Syphon bend,"

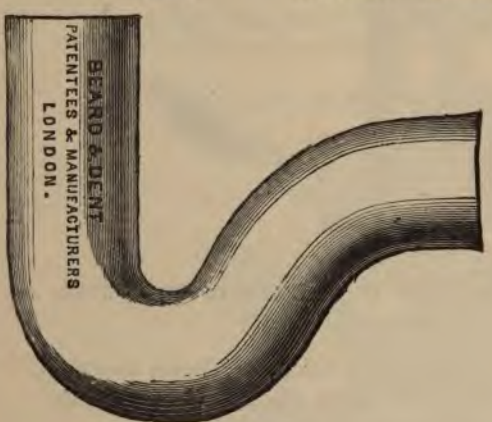


Fig. 8.

Fig. 9.

which, after all, if one particularly desires a trap, is as good as any.

7. Waste Pipes.

(*a*) Sink wastes. All waste pipes from sinks are provided with a small trap; this trap must be easy of access, so that any temporary obstacle may at once be removed, and the greasy deposit cleared out. Fig. 6 shows such a trap.

Occasionally these pipes deliver straight into the soil pipe. I cannot commend this course. The pipes should always deliver into an open channel leading to a trapped gulley or else into a proper receptacle, the air in which has no continuity with that in the house drain.

(*b.*) The waste pipes from baths, lavatories, &c., deliver sometimes into a special pipe, or else into a rain-water pipe; this I consider the best arrangement, but to connect them with the soil pipe, as is sometimes done, is a very faulty piece of construction.

8. CISTERNS (OVERFLOWS AND OTHER PIPES FROM).

Under this heading, it may not be out of place, perhaps, to describe the three kinds of cisterns which are connected with this system.

a. The cistern supplying bath, lavatory, &c., and "flushing" tanks of the closets.

This cistern is placed, whenever practicable, in a small but well-lighted room, situated just over the bath, lavatory, &c., which the cistern is to supply; thus it is accessible at all times. The overflow pipe from this cistern discharges into the open. A pipe leads from this cistern to—

b. The cistern for flushing the closets. This cistern, often known as a "water-waste-preventing tank" is constructed to hold a certain amount of water, considered sufficient for the purpose of flushing the closet. As I have already intimated, this quantity should not be less than three gallons.[2] In the above arrangement there is sufficient discontinuity of air between the flushing cistern and the bath supply cistern.

(*c*) Drinking-water cistern. The material of this reservoir should be slate if the surrounding construction will admit of so great a weight; if not of slate, then some other material must be chosen, having due regard to the quality of water to be stored therein; this cistern is placed in position of easy access,

[2] The single discharge is often limited to two gallons.

and supplies draw-off taps only—these should be placed in handy positions, for it must be borne in mind that however stringent orders may be given to servants, they will invariably choose the handiest tap from which to draw the drinking-water.

This cistern has no connection, either direct or indirect, with the water-closets.

9. Rain-water Pipes.

These pipes are made of cast iron, specially protected against the weather.

All gutters discharge into the vertical ("down") pipes, and these again into some system of yard drainage, or into some form of splash-pit.

We next pass on to the consideration of System III.

SYSTEM III.—THE "CONTINUOUS."

THE arrangement of pipes for house-drain ventilation on this system is doubtless based on the suggestion "b" of the Local Government Board, and, as indicated in my discussion of the origin of the Intermittent System, I will now proceed to explain this second suggestion.

The paragraph containing it runs thus:—

"In every case where the foregoing arrangement of the openings "to the drains may be impracticable, one opening shall be obtained "by carrying up from a point, as near as may be practicable to the "trap (disconnecting trap), a pipe or shaft vertically, to such a "height, and in such a manner, as to effectually prevent any escape "of foul air from such pipe or shaft, into any building in the "vicinity thereof.

"Such opening shall also in every case be situated on that side "of the trap which is nearer to the building.

"The second opening, being at a point as far distant as may be "practicable from the point at which such last mentioned shaft "shall be carried up, shall be at or near the level of the ground, and "shall communicate with the drains by means of a suitable pipe or "shaft.

"Par. V.:—Provided always, that the soil pipe of any water-"closet may be deemed to provide the necessary opening for "ventilation which would otherwise be obtained by means of such "last mentioned pipe or shaft.

"NOTE.—Subsection V. permits the soil pipe of a water-closet "to be used as one of the requisite ventilating shafts, where in "point of size, position, and other particulars, it complies with the "conditions laid down for such pipes."

If the soil pipe be utilized as this latter pipe, we have the "Continuous" system of house-drain ventilation.

It now remains to see what special sanitary apparatus are used, and what is the place assigned to each appliance.

1. The Disconnecting Trap.

This appliance is situated between the public sewer (or cesspool, as the case may be) and the house drain; it stands in a bricked chamber, and is easy of access at all times.

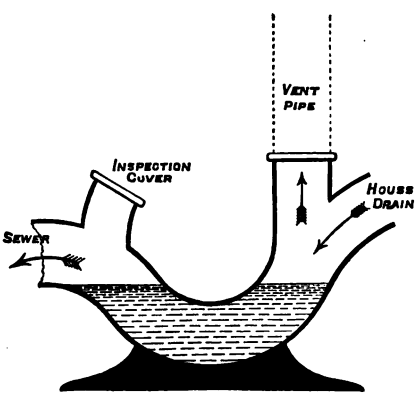


Fig. 10.

Where the exigencies of the case demand, the chamber in which it is placed takes the form of some patent manhole, with special cover,—as Angell's or Dyer's.

The trap itself (fig. 10) consists of a syphon bend, standing on a square base, which goes far to ensure the level fixing of the trap. Another advantage is that the inlet from the house drain is well above the level of the outlet from the trap to the sewer, thus promoting rapidity of current and therefore tendency to *self-cleansing*. The trap is provided with two

points of access, one for inspection, and the other for the ventilating shaft.

A good form of this kind of trap is that manufactured by Messrs. Stiff.

2. The House Drain.

Material.—Well-burnt, hard, smooth, glazed earthenware, attention being paid to the fact that the "*socket*" *is made with the pipe, not merely jointed on.*

Pipes laid.—On concrete bed, and in straight lines; when bends are absolutely unavoidable, care is taken to use bent pipes, right angle turns being thus avoided.

"*Fall*" *of pipes.*—Depends in a measure on size (and *vice versâ*), levels are tested accurately after laying every few lengths, and also attention is paid to the fact that "joints" are water-tight.

Joints.—In cement pipes: the joints are not compressed too firmly from without, else the result is a series of collar-like obstructions internally, which would soon impede passage of matter; wiped clean from within the pipe.

Position.—Above ground preferred, where, if any leakage should occur, attention will be at once called thereto.

At either end of the house drain is situated an inspection cover, so that when both ends are open the whole length of the drains can be inspected and sweeping instruments used with the greatest advantage.

3. Appendages of, or Connections with, House Drain.

(*a*) *Soil-ventilating pipe.*—On the house side of the trap disconnecting the drain pipe (fig. 11, "C, D") from the public sewer or cesspool, a pipe untrapped leaves the house drain and runs up the outside of the house; the free end of this pipe (C) is carried above the roof, and is fitted with an exhaust ventilator. This ensures the exit

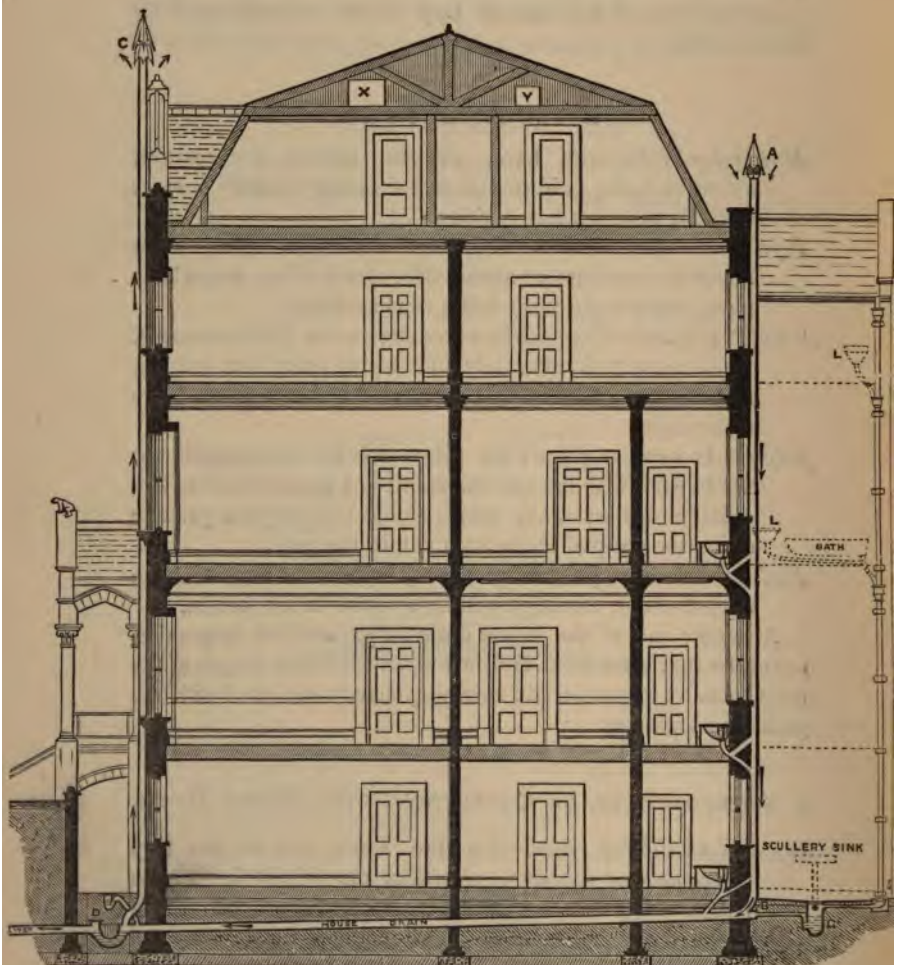


Fig. 11.

of all foul air (which should by any chance bubble up through the water in the disconnecting trap); thus, from this source, at least, no foul air can enter the house drain. The free end of this pipe, of course, terminates far away from windows or chimneys.

(*b*) *Soil pipe proper.*—At the other end of the house drain (e.g. in town houses at the back of the house) a pipe "untrapped" leaves the house drain, and is also carried to some point clear of the roof, not quite so high as pipe "C D." On the free end (A) of this pipe (A B) is fixed an injecting ventilator, which is *always* injecting a stream of fresh air into the house drain IN THE DIRECTION of the sewer or disconnecting trap. This is another reason why the sewer gas, if it "forces" the disconnecting trap, cannot enter the house drain, and so go on and find its way into the closets,—"because there is always a stream of air flowing in the other direction" (i.e. away from the closets).

Into this pipe, which is also the fresh-air inlet-pipe, the closets lead. The advantage of this arrangement is that in this "continuous" system the mere fact of putting the closets in action accelerates (and does not reverse, as in the "intermittent") the natural air current.

The soil pipe discharges straight into the house drain without the interposition of any dip-trap or other contrivance, which would impede the passage of matter. The connections between the two pipes mentioned above is effected by means of a curved piece of piping. This I consider the best arrangement, as appears from the following considerations:—

Our aim should always be to carry off as quickly as possible from the precincts of the house all waste products. Now in the case of matter from the closets, it is obvious that before it can reach the sewer it has to travel in two distinct directions—one vertical (i.e. down the soil pipe), and the other horizontal (i.e. along the house drain). It is assisted by two main forces —a *vis insita*, the momentum acquired by falling bodies,—and

the press of water behind it, if a good flushing supply is used. When it comes to traverse the horizontal pipe, the momentum would result in complete inertia if the junction between the two pipes were a right-angle one; and, in any case, the flow of water is infinitely slower along the house drain than in the soil pipe. Therefore obviously such a junction must be effected as will decrease the inertia, or, in other words, transmit as much of the force acquired during the vertical descent to the horizontal, as possible. Now let us work out this theory diagrammatically and mathematically.

Let the impetus imparted by the flush of water, ***plus*** the momentum acquired by falling through the vertical pipe, be "*y*," and let the velocity with which matter can be propelled along the (almost) horizontal house drain be "*x*;" then, to obtain the best result, we must make the most of our two forces by taking some direction between the two in which they respectively act. The method in which this direction is found may be roughly stated as follows:—

[It is obvious that the numbers "*x*" and "*y*," taken above, are purely arbitrary, and have no significance attached to them beyond the illustration.]

"If any two forces, acting at a point, can be represented in magnitude and direction by two straight lines, and if a parallelogram be constructed with those lines for two of its adjacent sides, then the diagonal of the parallelogram (which passes through the point from which those forces are presumed to act) shall represent the 'resultant' of those two forces in magnitude and direction."

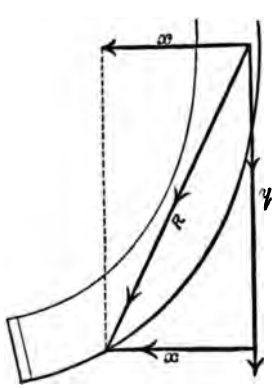


Fig. 12.

In the annexed diagram (fig. 12) the curved lines represent the bent junction-pipe connecting soil and house-drain pipes.

Another great advantage of the curved junction over the "right-angled junction" is, that all projections for the accumulation of soil are avoided, and, at the same time, the passage of the soil is least checked. The advantages over dip-traps are too obvious to need comment.

The material of which the soil pipe is made is 7 lb. *drawn* lead without any seam. This description of lead-piping is found to be the most uniform in thickness and stability. At intervals of four feet the pipes are "tacked" to the wall; this prevents any danger of detachment from house fittings or of disruption. The joints in the pipe are best "wiped joints" (fig. 13). The time occupied in making these is certainly considerable, but it is well worth paying for.

Fig. 13.

(*c*) *Grease trap.*—(Fig. 14.) "This trap is designed especially to provide a grease trap which can be *easily cleaned*, thus removing the one objection so often raised against grease traps in general.

"To meet this object, the interior is fitted with a movable iron bucket, in which all floating grease or scum is collected on the top of the water, whilst the solid particles, or sand, &c., fall to the bottom. The bucket is provided with slits all round, about 6 inches below the level of the water, through which the liquid flows up the outlet bend and away into the drain. It also has a handle in the centre for lifting it out.

"The outlet pipe is of a special form, viz. the upper part of the bend and the drain pipe therefrom is 4 inches in diameter, whilst the lower part, where it joins the gully, is only 3 inches. This will prevent any possibility of syphoning, as the outlet pipe cannot run full. Syphoning is known to be a common occurrence with many forms of grease traps.

"By combining the grease trap with the yard gully the following advantages are gained:—

"1. It is certainly economical as answering a double purpose.

"2. The trap is better flushed.

"3. The liquid in trap becomes diluted with rain-water, and therefore less liable to smell.

"4. The grease trap is well ventilated.

"5. One cleansing answers for both. Thus, if your grease trap is kept in proper order, you will never find the yard flooded in case of storm, as so often happens from gullies not being kept clear.

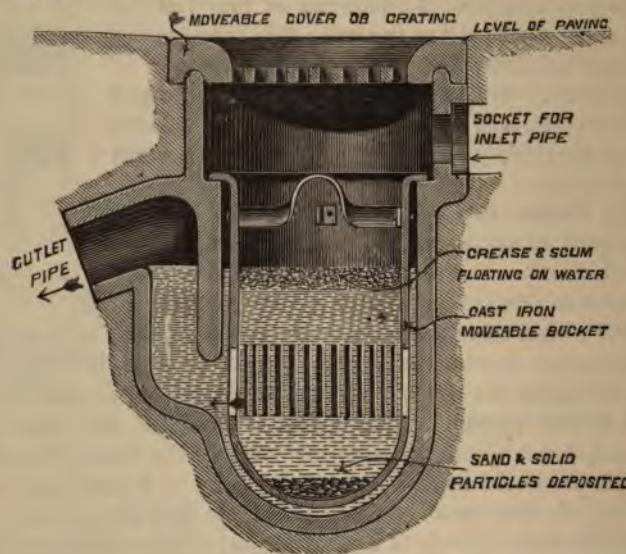

MOVEABLE COVER OR GRATING
LEVEL OF PAVING
SOCKET FOR INLET PIPE
OUTLET PIPE
GREASE & SCUM FLOATING ON WATER
CAST IRON MOVEABLE BUCKET
SAND & SOLID PARTICLES DEPOSITED

Fig. 14.

"On this drawing only one inlet socket is shown; but the trap can be made with several if required to take rain-water pipes or other wastes.

"When the trap requires cleansing, the cover grating is removed, and the bucket gently raised by means of the handle, so as to allow the liquid to flow off until it is below the bottom end of the slits; the bucket will then be found to contain all

grease, scum, and solid matter that has been collected in the trap with just sufficient water at the bottom to enable it to be easily emptied out; it can then be rinsed out and replaced.

"In this manner the trap can be cleaned by any servant or boy without even soiling the hands; whilst, if constantly emptied, there will be little or no smell arising therefrom, and your grease trap need no longer be known by the opprobrious epithet of 'stink trap.'

"PERCIE COWPER."

[The author is indebted to Percie Cowper, Esq., architect, Forth Bridge Works, for the above description.]

(*d*) *The splash pit.*—This is a contrivance for receiving the *ejecta* from baths, lavatories, &c., and also rain-water; in fact all water which may pass down the rain-water (or other similar) pipe. It is situated at the foot of this pipe, which is led into it through a grating, and is on a higher level than the "yard-gully grease trap," as all the waste water which it receives from the house has to be projected into this latter appliance (yard gully), after passing which, it flows on to the drain.

4. VENTILATORS.

(*a*) *Downcast.*—There is, as we have seen, a downcast ventilating head fixed on the soil pipe, which, acting always automatically and being sometimes aided by the downward suction caused by the flushing of the closets, performs very efficient work in the right direction. As a brief description, the following may be taken as sufficient:—

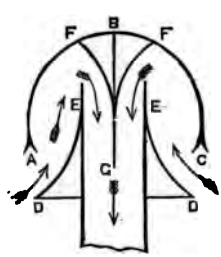


Fig. 15.

The ventilator (fig. 15) consists of a shaft surmounted by a dome. The dome is connected to the shaft by means of "baffle plates," which divide the space between shaft and dome into equal compartments.

Beneath the dome is fixed a "wind guide" (which surrounds the shaft as a collar, and is attached to both shaft and

"dome") for conducting the air into the dome, whence, owing to accumulated pressure, the current passes in the direction in which there is least resistance, i.e. down the shaft, and so on to the house drain.

At first sight it might appear that the air could only enter from one side of the ventilator (namely, that against which the wind impinges); such, however, is not the case, as the air, pressed by accumulated pressure down one side of the ventilating shaft, induces a current in the same direction over the whole area of the pipe. Fig. 17 shows an ornamental design of this ventilator.

Fig. 16.

Fig. 17.

Fig. 18.

(*b*) *Upcast* (figs. 16 and 18).—This ventilator consists of three essential parts: (1) the shaft, to which is fixed (2) a dome-shaped chamber or "wind chest," and (3) a "cap," which surmounts the whole structure. From whatever direction the wind strikes the dome, its upward curves cause the current to pass across the orifice in the dome, thus inducing a current at right angles to itself up the shaft, and so extracting the foul air from the drain below.

If the wind strikes down vertically on the top of the ventilator, the downward curves of the "cap" deflect the current, causing it to rush down the outside of the ventilator, past the space between the cap and dome; this vertical current induces a draught at right angles to its own path (i.e. horizontally between the cap and dome, and so over the ex-

tracting orifice of the ventilator), which, in its turn, creates an exhaust current vertically up the shaft of the ventilator, and extracts the foul air from the drain. Fig. 18 shows ornamental design of same.

Both ventilators are protected by wire gauze to prevent birds building their nests therein.

5. Closets.

In this system, if applied in its entirety to a house, a trapless closet is used, and some contrivance, such as a valve or

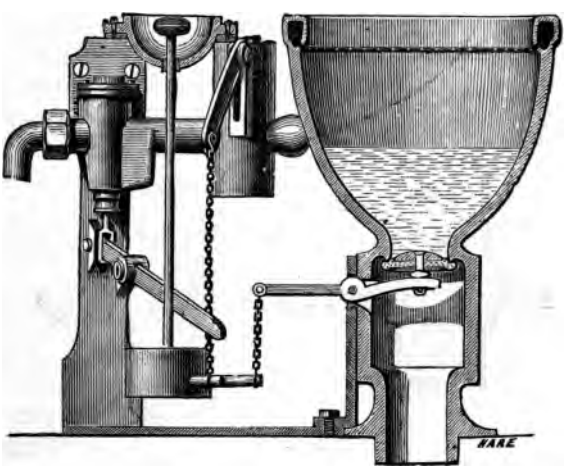


Fig. 19.

a "temporary plug," which closes the outlet of the closet, and is raised on "flushing," is substituted for the trap; the valve, or the "temporary plug," performing all the necessary functions of the trap, with none of its disadvantages. Such a contrivance will retain the necessary quantity of water in the basin of the closet, and thus prevent the reflux of any air. [I am treating only of a *ventilated* system of house drainage.] When the valve is opened, or the "temporary

plug" raised, the contents of the closet basin pass at once into the soil pipe. Fig. 19 shows a closet fitted with such a valve apparatus, and fig. 20 a closet with the "twin basin." Under each closet is fitted a "safe," which, in the event of an overflow taking place, intercepts the water; the waste pipes from these safes discharge directly into the open, and are fitted at their orifice with clack valves opening outwards;

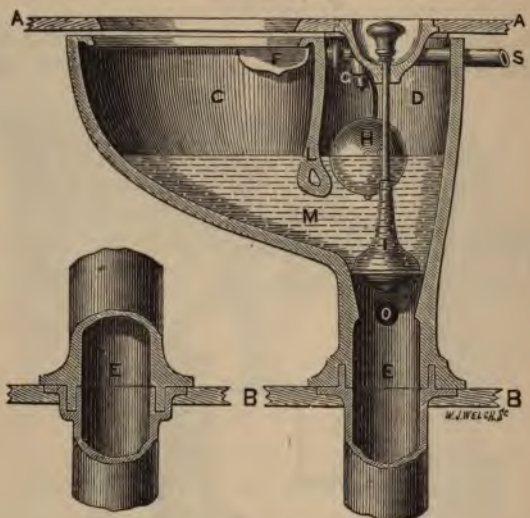


Fig. 20.

this allows the free passage of water from within outwards, but prevents any reflux of air.

6. Traps.

These appliances are not needed under closets, and are simply a means of impeding the passage of matter from the closets to the soil pipe.

7. Wastes.

(*a*) *Sink wastes.*—The waste pipes from sinks, are provided with a small trap, which is easy of access; this trap consists

merely in the waste pipe being recurved upon itself, so as to always retain a little water.

The traps are provided at the bend with a screw-down inspection cover (fig. 9, p. 24) so that they can very easily be cleansed, or freed from any obstacle which may impede the free passage of water.

The pipe which leads from the scullery sink discharges into the grease trap before mentioned, and of which a drawing is given on page 34.

(*b*) *Bath wastes.*—The wastes from baths deliver into the rain-water or other suitable pipe, and this discharges into a splash pit, which communicates with the grease trap.

Under every bath there is a "safe," which, in case of overflow from the bath, conducts the water to the exterior of the house by means of a discharge pipe, fitted at its external orifice with a "clack valve," similar to that described under "closet safes."

8. Cisterns.

There are separate cisterns, for storing the drinking water and for supplying water to the closets, so that all risk of contamination of the drinking water by drain gas, is avoided.

Where possible the drinking-water cistern is constructed of slate; but, owing to the great weight of this material, it cannot always be used. This cistern is provided with a waste pipe (fitted with an air-tight plug), towards which the bottom of the cistern slopes gradually. This arrangement facilitates cleansing.

The waste pipe discharges into a rain-water head.

With regard to the overflow pipe it must be borne in mind that the value of this pipe is simply that it is an indicator of accident, and therefore it is made to discharge into the open, at a point where, if water passes from it, attention will at once be called to the fact.

The drinking-water cistern supplies taps exclusively; these are situated in convenient positions.

From the cistern supplying water to the closets, the water

is run off into each separate flushing-tank by means of a special pipe; the main cistern can thus also be used to supply the baths, lavatories, &c.

All supply pipes are fitted with stop-cocks.

9. Rain-water Pipes and Gutters.

These pipes are made of either lead or specially prepared and "weather-proofed" iron, the gutters (horizontal—or nearly so) discharge into the head of the rain-water (vertical) pipe, and the water is discharged from the lower end of this into the splash pit, thus serving, in time of storms, to flush the house drain.

Note.—The terms "intermittent" and "continuous," of course, strictly apply only to the *system* of drain *ventilation* in either case; but I have found it convenient to identify the terms, more or less, with the *systems of sanitation*.

GENERAL CONSIDERATIONS.

IT will be well here, I think, to give a *résumé* of the methods of house-drain ventilation which we have had under discussion.

If my readers care to refer to Knight's "Bye-laws," they will there see some diagrams showing the various suggestions of the Local Government Board, carried out.

Briefly, there are the following ways of effecting the ventilation of house drains and soil pipes: the different schemes may conveniently be classed as under.

A. House drains and soil pipe ventilated independently of one another.

(*a.*) *House-drain ventilation.*

(i.) By placing the inlet pipe, in the area, fore-court or garden in the front of the house, between the disconnecting trap and the sewer, and by carrying up an outlet pipe from some point of the drain far removed from the inlet (e.g. in the back-yard). This latter shaft must in no case be less than ten feet high, and must terminate far away from windows, doors, and chimneys.

(ii.) By transposing the above-mentioned pipes.

(*b*) *Soil-pipe ventilation.*

(i.) The soil pipe can be ventilated on the "Intermittent" system as in fig 4, p. 19.

(The objections to this I have already urged, viz. "reversal of the current.")

(ii.) A dip-trap can be used, and the rain-water pipe made to serve as the fresh air inlet (fig. 3); an arrangement which I consider bad, for, during the reversal of the current, the foul air would find egress at the rain-water head, which is often situated close to some bedroom window.

(iii.) The inlet pipe to the soil pipe may be carried up to the roof, being surmounted by a down-draught cowl. This plan is, to say the least of it, cumbersome, and also entails additional expense.

In all the above cases the soil pipe is ventilated on the "Intermittent" system, but the current through the house-drain is not materially affected.

(iv.) Lastly, the soil pipe may be ventilated on the "Continuous" principle, viz. the soil pipe may be fitted with a down-draught cowl, while the exhaust (or foul air exit) shaft may be fixed to the dip-trap and carried up to the roof to a point higher than the summit of the soil pipe.

This again seems to me a very clumsy design, and one intended, simply and solely, to increase the costliness of sanitary work. It is, however, tolerably safe, but a great objection is the presence of the dip trap.

B. The house drains and soil pipe ventilated by one single current of air.

(i.) The soil pipe may be made the upcast on the "Intermittent" principle.

This is a most ill-devised scheme; as I have already stated, it is the worst form of "Intermittent" ventilation (see fig. 2); or, better, the inlet pipe may be carried up to the roof of the house.

(ii.) The soil pipe may be used as the down-cast, or inlet, and a special upcast pipe be provided at the other end of the house drain, as in fig. 11. This last arrangement, by which both house drain and soil pipe are ventilated on the "Continuous" system, is, without doubt, the simplest and best yet devised. The safeguard, on this plan, is not in

any particular form of dip-trap, closet trap, or other sanitary appliance; indeed, the absence of all complicated apparatus is a distinguishing feature of this system, and the extreme simplicity of the whole scheme renders it adaptable to almost any and every class of building.

As a system of ventilation (apart from special appliances, which can of course be highly finished or the reverse), it has been applied at a very trifling outlay.

In writing the above, I am very far from intending to eulogize "cheap" sanitary work; all work of this nature should, as I have before stated, be of the very best, and must be paid for as such, whether it is executed for the palace of the sovereign or for the cottage of the peasant; but what can, and should, especially in the latter case, be avoided, is the wholesale introduction of needless appliances, which has hitherto been so much *de règle.*

Cheapness need not always mean "scamped work," for labour may be so minimized as to preclude the possibility of scamping; in fine, cheapness may be synonymous with simplicity of system.

* * * * * * *

1. The Disconnecting Trap.

There are many forms of this appliance in use now, all of more or less efficiency; but, before particularizing any special pattern, it may not be inappropriate to remark on the functions which this trap is expected to perform. Briefly, it is intended to prevent the passage of sewer gas from the public sewer to the house drain, and to allow matter to pass through it in one direction only (viz. from the house to the sewer). I think I shall be able to demonstrate tolerably clearly that there are times when a disconnection trap, *per se*, is indeed a "broken reed" to lean upon for defence against sewer gas.

For instance, suppose the public sewer to be running half-full, having, of course, in its upper half a certain amount of sewer gas, more or less diluted with air; if the flow of sewage through that sewer is increased—causing it to run $\frac{3}{4}$-full—the space previously occupied by the gas is reduced from $\frac{1}{2}$ to $\frac{1}{4}$ of the sewer, and thus, according to the well-known law of Mariotte ("pressure of a gas is inversely as space occupied"), the pressure, or tendency to escape, of this thus-confined sewer gas is doubled, or, in other words, is increased by an amount equal to that of one atmosphere, or a column of water 34 feet high.

This increased pressure must cause the gas to escape, either into the street, if the gratings are not (as often is the case) occluded by some obstruction, or to force the disconnecting trap of the house drain, and so find easy entrance into the house system, unless adequate house-drain ventilation be provided. The former, being a matter concerning the local authority, it is beyond my province here to touch on; but the latter affects my readers directly.

This temporary increase in the flow of sewage, to which I have above made reference, is precisely the danger which we should most have to fear in an epidemic of cholera, such as is now running riot throughout the foreign capital most neighbouring to our shores.

During an epidemic the sewers would periodically be flushed, which would conduce in an alarming extent to the so-called ebb and flow of the sewage. That is to say, during, and for some time consequent upon, the "flushing," the increase of flow would, as we have seen, be pumping into our streets and houses, noxious air—in this case impregnated with cholera germs; whilst the return to the normal flow would leave much slime and filth on the wet sides of the sewer, to generate more noxious exhalations, which in their turn would be pumped out, as before, when the "flushing" process began again.

In all zymotic diseases the chief media through which infection is propagated are the waste products of the infected

subject, and hardly an easier way of coming under the influence of the disease can be mentioned than the passage of infected *miasmata* from house to house, owing to imperfect discontinuity of air between house drain and sewer.

When once the poisonous emanations have penetrated into the house drain—and, as we have seen, this is far from difficult—it is next to impossible, unless adequate means of escape is provided, for them not to find entrance into the house somehow or other. The channels of ingress are many; e.g. closets, overflows from cisterns, bath wastes, scullery-sink wastes (especially when hot water is used); and the germs of disease are very penetrating.

Disconnecting traps well constructed—and I know none better than Messrs. Stiff's—are most necessary adjuncts to all systems of house drainage; but I venture to say that they will not avail us much as a defence against the ingress into our houses of unwelcome *miasmata*, unless they are supplemented by a ventilation pipe situated between them and the house, as shown in fig. 11.

Whatever form of trap is used, the great points to be desired are accessibility, rapidity of cleansing, and proper arrangements for both ventilation and inspection.

Whilst on the subject of inspection, I may remark that the drain of a house requires "sweeping" from time to time; the performance of this function is not very difficult with a properly arranged disconnecting trap, placed in a manhole of sufficient size. The apparatus necessary for performing this operation is in many respects similar to a chimney-sweep's bundle of sticks, with one or two mechanical additions for removing any temporary obstacle which may be met with.

Most firms of sanitary engineers keep such apparatus, and the operation of sweeping the drain should not be a very difficult or costly one. It is, moreover, a good way of ascertaining if anything is wrong. Some firms contract for yearly inspections of the house drainage, and this operation would of

course be included. I cannot do better than commend it to my readers.

2. The House Drain.

In the old system the house drain was usually composed of brick, which, even when in good repair, is porous. This is clearly wrong, as it allows the passage of gas, and the percolation of fluid from within outwards, which obviously soon would become a source of great danger to the inmates of the house, if the drain ran under the house; or, on the other hand, if the drain were situated externally to the house, the percolation would go on into the subsoil, and would ultimately find its way under the basement, or, as is frequently the case in the country, to the well, the water of which is used for domestic purposes. The dangers arising from this blunder are too obvious to require comment.

3. "Appendages" of the House Drain.

The house drain in the Old system was provided with neither fresh-air-inlet pipe, nor with foul-air-outlet pipe, so that it was always full of sewer or drain gas, which, after having "forced the seal" of the disconnecting trap, traversed the old brick drain, and found entrance to the basement of the house, if the drain were (as was commonly the case) rotten. Thence some of the gas escaped into the house through "rat-holes," or any other imperfection in the kitchen floor, whilst the remainder of it passed on through the soil pipe (i.e. that pipe into which the closets lead), and, having forced the water seal in the D trap under each closet, part passed from that D trap up through the waste pipe from cistern, which led into the D trap (see fig. 1), and so on to the water in the cistern, and part through waste pipes also leading into that D trap from baths, lavatories, &c. (see fig. 1), and so found easy entrance into the house, being aided on its onward journey by two main forces, the *vis-a-tergo*, or high pressure at which it was gene-

rated, and the *vis-a-fronte*, or suction power exerted by a warm house.

Let us see how these evils are remedied in System II., supposing ventilation to have been applied, as is often the case, to an old house.

Now in this system it will be seen that the sewer gas has to pass through the house drain (carrying devastation with it, as before, if the house drain is faulty) till it comes to the soil pipe. Up this it is carried and is ejected clear above the roof.

Of course the evils of the gas passing up the waste pipe to the lavatory, or to the overflow pipe from the cistern, are here avoided, because those pipes are not in any way connected with the closet; but still we, in this system, are exposed, I think, to many risks from the sewer gas *being made to traverse* the whole of the house drain before being finally got rid of, and by the pipe into which the closets discharge being made to do duty as the foul-air-exit pipe.

Let us go further and contrast this system, II. (fig. 2), with III. (fig. 11), the "Continuous" system. Under this *régime*, there being two ventilating pipes, one, the foul-air-ejecting pipe, near the disconnecting trap, and the other, the inlet pipe (i.e. the soil pipe), at the end of the house drain, remote from the sewer, if any sewer gas should force the disconnecting trap, it is *at once* carried up the ventilating pipe, *before it can get to the house* drain (see fig. 11, C D); and, moreover, there is *always* a strong draught of air (induced by the "injector") passing down the soil pipe and through the house drain in the contrary direction to that which the sewer gas would take, thus ensuring a current of rapidly moving fresh air being always in the house drain and soil pipe. In this system we have, of course, a separate "sub-system" for the overflow and waste pipes from bath, lavatories, sinks, &c.; thus practically all dangers are eliminated.

It is, of course, preferable to have the house drain above ground, and in a conspicuous position; this, however, is not

always practicable. The bye-laws of the Local Government Board indicate one foot at least as the distance there should be between the floor of the ground-floor rooms and the house drains.

With regard to the material of which the drain should be constructed, the composition indicated in either the "Intermittent" or "Continuous" can hardly be improved upon. I do not, however, propose to give great prominence to this point, as my object is rather to point out how existing faults can be remedied most easily, than to indicate what materials "the trade" should use. I would, however, remind those of my readers who intend to relay their house drains not to be persuaded to "accept the lowest tender" for the work, but to have it well and carefully executed, under proper supervision, and by some competent sanitary engineering firm.

The introduction of the ventilating pipe in close proximity to the disconnecting trap (as is the case in System III.) is, I think, a very decided improvement; for this pipe here serves a double purpose:—it helps to keep up a continuous current of air always travelling in one direction in the house pipes, and also offers an escape to any sewer gas which may bubble up through the water in the disconnecting trap; for this gas cannot take any other direction, as it is opposed by the natural current (induced by the soil-pipe [downcast] ventilator) in the house drain. Moreover, the effect of matter passing down the soil pipe (i.e. when the closets are put in action) is to accelerate, and not reverse (as in the "Intermittent"), the natural air current.

Thus the danger (which I have dwelt on in the Intermittent system) of the inlet pipe becoming the outlet is avoided.

Neither of these pipes should be contracted towards the top (see fig. 11, A B and C D, and contrast with figs. 2 and 4).

The material best suited for the soil pipe is good-quality lead; for the ventilating pipe galvanized cast iron may be used.

Very often, as I have said before, in old town houses especially, from a variety of causes the persons interested

cannot be persuaded to have the house thoroughly overhauled, and all sanitary arrangements made perfect; they always want to know if "this" or "that" "won't do," as though they would make some compromise with their danger. It is a compromise of which I cannot approve, though, perhaps, it is very natural. It is a great nuisance, and—in very many cases also—a great expense (the fruit whereof will probably be reaped by another) to entirely refit the house from "top to toe."

In such cases the "continuous" system of house-drain ventilation affords an easy way out of the difficulty, as, wherever it is applied, the house drain and soil pipe will always have a current passing through them, and the house will be, as it were, surrounded by a belt of air in a more or less (according to the force of the wind) rapid state of motion. I should say that comparative immunity from danger might be thus secured at a moderate cost. As I have before hinted, very little difference, as far as regards excellence, exists between some of the sanitary apparatus found in the "Intermittent," and those of a like nature which I have identified with the "Continuous," system of house-drain ventilation; but it is obvious that the two systems differ considerably from one another as far as the merit and principle of ventilation is involved. The intermittent system has been in vogue for some considerable time, and exists now in many shapes and forms, all of which, however, agree in making the soil pipe the upcast shaft, whilst the inlet for fresh air is situated in places of varying proximity to the soil pipe. Some sanitarians advocate the inlet pipe being situated in the front of the house, by the "yard gulley;" others place it at the foot of the soil pipe, and ventilate the house drain separately. Some again suggest a charcoal "screen" being placed in the interior of the inlet pipe, so that, when the reversal of current takes place (and the inlet becomes a temporary outlet), the foul gases which are ejected should be deodorized by passing over the charcoal. This latter suggestion is, to my mind, the "unkindest cut of all," as it

effectually condemns the "Intermittent" system. Another suggestion, of a like nature, is to insert a "mica flap" ventilator in the inlet pipe, to prevent reflux of air.

But in all these modifications there is (as the name implies) a current varying according as the closets are at rest, or otherwise.

"Quot homines tot sententiæ" ("every sanitary engineer has his own appliances"); but an appliance is one thing, and a "system" is another, and, as far as I have been able to judge, until recently sanitary improvements have been carried out on the "Intermittent house-drain ventilation" system. I could, however, instance several houses to which the "Continuous" system has been applied, and has proved a great success; it has been aptly described as a "practical application of a common-sense theory."

(*c*) *The grease trap* (note *ante* System I., II. and III.)—I have used this term to include the receptacle for waste products from sinks, but often there is combined with this the yard gulley. There are many forms of these traps. Commencing in order of seniority, and, I think I may say, of inefficiency, we have the old "bell trap" and the "lip trap;" sometimes these when used solely for grease traps (especially the former), were situated in the interior of the house. I need not go minutely into the defects of these appliances; it is sufficient to say that the water in them frequently evaporated, leaving no "seal" of any kind, and the offensive exhalations proceeding from the decaying refuse matter of the sink were very injurious to health; often, to make matters worse, these traps communicated direct with the house drain, and if the trap to the sink itself were absent, the results of the above arrangement were very dangerous.

I think it an excellent plan to combine the grease trap with the yard gulley, as is done in Mr. Percie Cowper's "combined" trap, a drawing of which, with description, will be found on page 34 (fig. 14).

While on the subject of grease traps, it will be well to mention that waste pipes from sinks should all be provided with traps (a mere bend in the pipe being sufficient) with an inspection aperture, and screw-down cover, so that the trap can be periodically cleansed from any solid matter which may collect therein. For a drawing of this trap the author is indebted to Messrs. Dent and Hellyer (fig. 9).

(*d*) *The splash pit* (see *ante*).—I have adopted the latter name because it seems to me to individualize the appliance, which is in reality a small "yard gulley." In the "continuous" system it is utilized for the reception of the waste water coming from the baths and lavatories, the wastes from which lead into the rain-water pipe; this pipe discharges over the splash pit, and the splash pit empties into the yard gulley and grease trap. This is no doubt as good a way as any of getting rid of rain-water and waste water generally. In the "Intermittent" system, as I have indicated, this receptacle occupies various positions, according to the special exigencies of the case, and depending on the exact use for which it is intended.

4. VENTILATORS.

The very vexed question, as to the utility of these instruments, is one which has been long and hotly debated, on the one hand, by the proprietors and manufacturers of various exhaust ventilating patents, and on the other by the originators and upholders of the now notorious Kew tests.

I append a letter which appeared a short time ago in the *Sanitary Record*, as it appears to me to throw a little light on the question.

"VENTILATION AND VENTILATORS.

"This subject leads to more controversy than any other "connected with building, for the reason, we suppose, that "air is felt, but not seen, and few professional men take the

"trouble to learn the laws which govern the direction of air "currents. The following remarks on the subject commend "themselves to us on account of their fairness, and the "desire evinced to discuss the subject, and to remove much "of the misapprehension which, partly through ignorance, and "partly through the wilful misrepresentation of interested per-"sons exists in the minds of the public. 'The great agents "'upon which we depend for natural ventilation are three in "'number. First, the law of diffusion of gases. Secondly, "'the power of the wind (which occasionally has to be "'"manipulated," and herein lies the advantage of using auto-"'matic ventilators), and thirdly, the movements produced by "'the difference in weight of columns of air at different "'temperatures.

"'1. It is a well-known fact, of course, that every gas tends "'to "diffuse" inversely as the square root of its density; but "'perhaps the general public are not so well acquainted with "'the following fact, that this tendency to diffusion is so great "'as to take place even through brick and stone—of course the "'amount of "ventilation" which is obtained in this way is "'practically *nil*; but "diffusion" becomes a very important "'factor in ventilation, as soon as we come to deal with "inlet" "'and "outlet" shafts.

"'2. The wind may be utilized directly as a ventilating "'agent (ventilation by "perflation"), but it is not in that sense "'that it affects our present subject. When a body of air "'is in motion (or, in other words, when the wind "blows") "'it sets in motion all the air in its immediate vicinity. Air is "'propelled before it, and it causes a partial vacuum on either "'side of its path, towards which vacuum all air in the "'vicinity flows at (or nearly at) right angles. Thus it is that "'the upward current in chimneys and ventilating shafts is "'obtained.

"'The wind may, however, by the pressure which it exerts, "'amounting often to 8 ounces to the square foot, or by "'blowing down the orifice of an open shaft, impede ventilation,

"'and in such cases the utility of properly constructed "'ventilators is manifest.

"'3. If the air in any compartment be heated by a fire, or "'by animal life, or if it be impregnated with vapour, it will "'expand, and if there be any outlet, part of it will escape, and "'that which remains will be lighter than an equal volume "'of the air external to the compartment: the external air "'will then rush in through every chink and crevice till "''equilibrium' is established.

"'Here, again, is a very important factor, which, if we will "'only allow it so to do, will assist us much in providing "'an efficient system of ventilation.

"'Having briefly considered the natural forces which assist "'ventilation, let us now inquire into the real use of ventilators. "'All that should be expected of these instruments is that "'they should materially assist the natural up-current, if it "'be sluggish, and prevent the wind from blowing down the "'open pipe (i.e. prevent the wind from temporarily reversing "'the natural air current) by deflecting it, and causing it to "'pass over the orifice of the ventilator, thus ensuring the "'good effects of the wind, and guarding against its downward "'pressure. They seek to assist the exhaust current by "'offering to the wind a larger orifice to extract from than "'would be afforded if the shaft terminated in a plain open "'end. They seek to guard against the ill-effects of the wind "'by deflecting it (by means of "Louvres," "domes," "cones," "'and other contrivances too numerous to mention), and "'causing it to pass straight over such extracting orifices "'(or orifice) as may exist in the ventilator.'

"Automatic ventilators may, we think, be conveniently "divided into two main groups:—

"A. Fixed-headed ventilators.

"B. Revolving or rotating ventilators.

"And we may again subdivide A into—

"A.—1. Ventilators using the extracting power of the wind "horizontally.

"A.—2. Ventilators using the extracting power of the wind "vertically.

"Whilst group B may be classed—

"B.—1. Cowls revolving on the Archimedean screw prin- "ciple.

"B.—2. Cowl rotating on fixed bearing-points.

"With regard to unfortunate 'Group B.' in general, the "following are very great disadvantages:—The friction caused "by the constant rotation. The constant wearing away of "'bearing-points,' &c., and liability to get out of order by "'canting' to one side, &c. Requiring attention in the shape "of oiling and so forth.

"When we come to consider the efficiency, or the reverse, "of the 'Archimedean screw pattern' of ventilators, we are "led to propound to ourselves the following problem:—Under "favourable conditions the up-current in a plain upcast shaft "(of say 3-inch diameter) is 500 feet per minute; to obtain "this speed (or, in other words, to allow this amount of air to "pass), at what rate would a 'screw' of this pattern have to "revolve? Shall we say thirteen times per second?

"With regard to arriving at the relative merits of the many "'fixed-headed' ventilators which are now offered to the "public, we are met at the outset of our inquiry by the great "difficulty of the various sizes of 'heads' which we see "attached to—say a 9-inch diameter pipe—and to attempt to "arrive at any accurate relative results from the discrepancies "arising from this source is like comparing the results obtained "from one engine whose driving wheel is 8-feet diameter with "the results obtained from another having a driving wheel of "4-feet diameter.

"A scheme for testing the relative merits for all fixed-head "ventilators, on some basis of equality, we append,—

"1. That the ventilators should be tested on the U tube "system.

"2. That the same anemometer be used throughout the "testing.

"3. That the term 'Ventilator' be understood to mean 'the "apparatus from the point where the plain shaft ends, to the "extreme summit of such apparatus.'

"4. That the 'Ventilator' shall be able to be contained "within a cube of definite dimensions.

"5. That the length of pipe attached to each such "'Ventilator' shall be the same in every case.

"6. That all such sizes and dimensions shall be agreed upon "prior to competing.

"Hoping that the above will draw forth the opinions of some "of your correspondents.—We are, your obedient servants,

"SHARP AND CO."

(The *Sanitary Record*, Oct. 15th, 1884, p. 189.)

The two following are also extracts from letters which appeared in the same journal a short time after :—

"VENTILATION AND VENTILATORS.

"The letter from Messrs. Sharp and Co. under the above heading, on page 189 of your October issue, is one of the best I have read for a long time upon the subject.

"Testing on the U tube is very good. This is not a new idea, as it was done by Mr. S. S. Hellyer along with other plans. The tests should not be confined to that plan alone, as the double tube system with two anemometers (as done by Mr. Hellyer) is also a good plan. Another plan, which I think would be useful, would be to test the ventilators—either one, two, or more at a time—on separate pipes, and have a large metal or wooden box with two glass panes in it, and a deep self-closing valve, and mark which of the ventilators opened this valve best and kept it longest and widest open.

"The ventilators tested should be freely exposed to the wind; or if artificial wind be produced, it should be of sufficient volume to be a good and fair imitation of the wind, and such 'wind' should have sufficient scope to fairly envelope and freely pass all the ventilators. From want of attention to this,

some intended relative testing I lately saw was quite useless in my opinion, so far as giving any real comparative results was concerned.

"I quite agree with Messrs. Sharp and Co. in their condemnation of the use of movable cowls for exhaust purposes, as they often stick fast and stand the wrong way. Hence, for permanent use they are not to be commended; and I say so even although I patented in 1877 the Glycerine-jointed Veering Cowl. After a long series of experiments with them I have given them up entirely in favour of the *fixed* exhaust ventilators, and the question to decide is—Which of these is the best?

"I am, &c.,

"November 5, 1884. "W. P. BUCHAN."

"VENTILATION AND VENTILATORS.

"Referring to Mr. W. P. Buchan's letter in your November number, p. 241, we would suggest a competitive test on some such basis as the following:—

"1. That the term 'ventilator' be understood to mean 'The apparatus from the point where the plain shaft ends, to the extreme summit of such apparatus.

"2. The 'ventilator' to be capable of being contained within a cube of given dimensions.

"3. The U tube used for testing to rest on a pivot, so that it could be rotated as occasion demanded—(i.e. to ensure the wind blowing directly through the U)—neither ventilator being allowed to get to windward or to leeward of the other.

"4. The circumference of the shaft immediately below the 'ventilating heads' to be marked off in eighths of a circle, numbered 1 to 8, and tests to be made in each of the eight positions.

"5. Eight tests to be taken with ventilator 'A,' on arm '1' of the U tube, while ventilator 'B' is on arm '2,' and eight more tests to be taken with the ventilators transposed.

"On some such basis as urged in this and our previous letter, p. 189, a reliable result could be obtained.

"For our own part, we are willing to enter into competition with any firm who will agree that the loser shall forfeit a specified sum of money to a given charity.

"This suggestion seems to us more practical than making statements to the effect that 'We have obtained . . . medals,' that we were 'unaware that such and such tests were taking place,' or that 'our ventilator is the best in the market.'

"With regard to the U tube test not being a new idea, we did not for one moment suppose that it was. Our aim is not so much to seek after novelty, nor to lay claim to originality, as it is to endeavour to become apt exponents of laws which are founded on natural phenomena.

"December 10, 1884. "SHARP AND CO."

About the same time the following appeared in *Health*:—

"VENTILATOR TESTING.

"SIR,—As there seems to be a desire to arrive at the relative merits of the many ventilators now before the public (some manufacturers apparently not being satisfied with the I.H.E. results), we beg to be allowed to trespass on your valuable space to submit some scheme of testing.

"1. That the term ventilator be understood to mean the apparatus from the point where the plain shaft ends to the extreme summit of such apparatus.

"2. The ventilator to be capable of being contained within a cube of definite dimensions.

"3. Ventilators to be tested on the U tube system.

"4. The U tube to rest on a pivot, so that it can be rotated as occasion demands (i.e. to ensure the wind blowing directly through the U), neither ventilator being allowed to get to windward nor to leeward of the other.

"5. The circumference of the shaft immediately below the ventilator to be marked off in eighths of a circle (numbered 1 to 8), and tests to be taken in each of the eight positions.

"6. That such shaft be in all cases of the same length.

"7. Eight tests to be taken with ventilator A, on arm 1 of the U tube, while ventilator B is on arm 2, and eight more tests to be taken with the ventilators transposed.

"8. That the ventilators be also tested head to wind, to ascertain the value of the ventilator to 'prevent down-draught' (Parkes, p. 160).

"On some such basis as this a reliable result could be obtained.

"We would beg leave to say that we are willing to enter into competition with any firm who will agree that the loser shall forfeit a specified sum of money to some charitable institution.

"We think that this tends more to the practical solution of the vexed question than do vague statements of 'having won so many medals,' whether in open competition or in a 'duel,' and is also more to the point than such vain repetitions as 'our ventilator is the best in the market.'

"Apologizing for encroaching so much on your space,

"We are, sir, your obedient servants,

"December 19, 1884. "SHARP AND CO."

5. CLOSETS.

The closet which best fulfils the following requirements should, I think, have preference :—

(*a*) A basin of such shape and size as to hold enough water, and to ensure thorough cleansing on "flushing."

(*b*) The cleanliness, or the reverse, of the basin should be at all times evident. Pure white-glazed earthenware is therefore to be preferred.

(*c*) If closet be trapped, the trap should be in one and the same piece with the closet basin.

Valve closets, though having many advantages, are undesirable on account of the metal fittings, which are liable to corrosion. Messrs. Capper's closet (fig. 19) is an exception to this rule. (See *ante*, p. 37).

Whether the closet should be trapped or trapless is a vexed question. For my own part, I say "trapless;" and

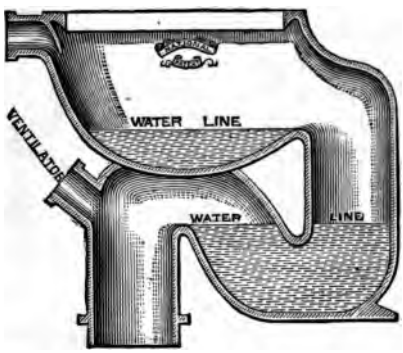


Fig. 21.

good examples of these are Pearson's twin basin (fig. 20), and the patent of Mr. E. G. Banner, C.E. (see *ante*, fig. 5); instances of good trapped closets are the "National,"

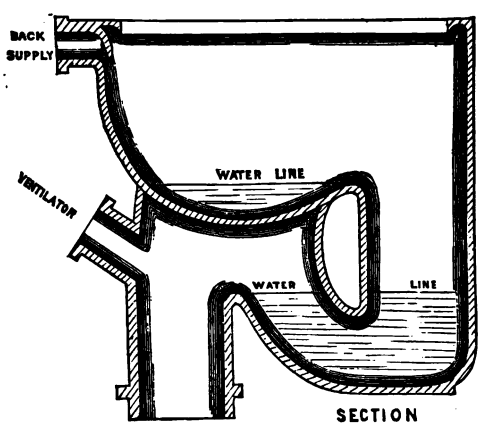


Fig. 22.

"Alliance," and "Crown" wash-out closets. (Figs. 22 and 23.) A trap of any construction is, and must necessarily

be, owing to its bends—an impediment to the passage of matters from the closet; when the drain and soil pipe are both perfectly ventilated, as in the "Continuous" system, traps will certainly do more harm than good. A simple valve, or perhaps better still, "a temporary plug," is, I think, the best arrangement for retaining in the closet basin the requisite amount of water, and for preventing reflux of air. Of course even these apparatus are not exempt from derangement owing to negligence; such as allowing a piece of paper, or other foreign matter, to fix between the valve or "plug" and the basin; but here, at all events, we see the derangement, and can, if we will, avoid its evil consequences; the same cannot be said of trapped closets.

Fig. 23.

Closets should be provided with "safes" underneath them, so that, in case of any overflow taking place, the water is prevented from damaging surrounding premises.

These "safes" should be provided with pipes leading straight into the open. At the outside end of such pipes "clack valves" should be placed, which prevent the passage of air from without inwards, but allow free passage of water from within outwards.

6. Traps.

A convenient form of experiment for demonstrating the fallacy of traps, as a seal against the passage of sewer gas, is the following:—

Take a U tube, fill it, say half full of water, connect one end of it with a caoutchouc tube (see that the joint is air-tight); at the other end of the U tube fix in, by means of a tightly-fitting caoutchouc cork, a piece of brass or other tubing

drawn to a point. Connect the caoutchouc tube with a gas burner, turn on the gas, and you will be able to force the gas

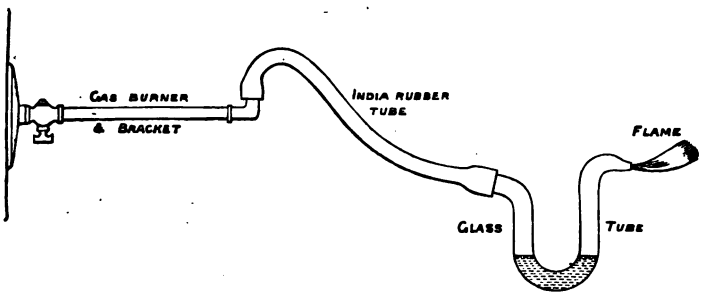


Fig. 24.

through your "water seal" in the U tube, and light it when it comes out of the orifice in the brass tube! (Fig. 24.)

7. WASTES.

(*a*) *Sink wastes.*—These pipes should be provided with a small trap immediately beneath the sink. The best form for this trap is a simple bend in the pipe, fitted with an inspection cap, so that any foreign matter or grease can be easily removed.

These pipes should deliver into an open channel leading to a trapped gully; the air in them should have no continuity with the air in the house drain.

(*b*) The waste pipes from baths, lavatories, &c., should also deliver into the open over a splash pit.

8. CISTERNS. { (*a*) Drinking-water cistern. (*b*) Closet-supply cistern.

There should be two main reservoirs in every house for storing water—one for the drinking-water and the other for the supply of water for closets and baths.

The cistern that supplies both closets and baths should be connected with small flushing tanks in each closet by pipes of about $1\frac{1}{2}$ or $1\frac{1}{4}$ inch diameter, according to height of fall.

The materials of which cisterns should be made depend on such a variety of circumstances, that I do not like to indicate any one in particular. The following may be cited as current views on this topic:—

Slate cisterns are the best, being cool, and not affected by the action of water. Objections: liability to break, and great weight. Slate, brick, and tile cisterns come under the same category, assuming that they are set with good cement, and not with common mortar.

Lead cisterns are injuriously acted upon by some kinds of water.

Galvanized iron may be regarded as a useful and inexpensive material for cisterns.

Zinc cisterns are objectionable, as water which is for any length of time in contact with zinc may produce symptoms of metallic poisoning, the water forming salts with the zinc, e.g. nitrates, chlorides, &c. A very useful material for coating metal cisterns is Colonel Crease's patent cement.

Whatever form of cistern is used, it should be carefully and thoroughly cleaned at least once in three months.

Whilst on the subject of water supply and storing, it might not be out of place to state briefly how water may be collected and stored, and what precautions this entails, and also what specimens of water suffer contamination by contact with lead cisterns, even if otherwise pure.

1. Rain Water.

The gases found in specimens of rain water are nitrogen, oxygen, and carbonic acid. This water, if carefully collected, is the purest natural water that can be found. Various other substances are, however, contained in it, amongst which may be mentioned sodium chloride, air, ammonia, and occasionally nitric acid, besides organic (vegetable) matter. If the water is collected near towns, more impurities are, of course, found; if collected at the seaside, sodium chloride is in excess.

Rain water, owing to absence of salts of lime and mag-

nesia, is very soft, and is, as we all know, prized very highly, especially by country folk, for washing purposes. Rain water is liable to contamination with lead and zinc.

2. Surface Water.

Water obtained from ponds, brooks, and surface wells is very liable to contamination. If obtained from ponds, all kinds of prejudicial foreign substances are found, such water never being fit for domestic use till it has been boiled.

Water from surface wells is specially liable to sewage contamination, and should be suspected; if it is found to contain nitrites and chlorides, this suspicion becomes almost a certainty.

"When nitrites occur in shallow well or river waters, it is highly probable that these waters have been very recently contaminated by sewage, for in the ordinary oxidation of sewage by percolation through porous earth, its nitrogen is at once oxidized to the maximum, nitrites being absent from the effluent water of intermittent sewage filters. But when fresh sewage is added to water containing nitrates, the latter are generally reduced to nitrites." (Frankland.)

"If, now, we find a sample of water which should be expected, naturally, to contain only 1 part of chlorine per 100,000, showing, say, 8 parts, we may usually infer thut this excess is derived from that very frequent source of danger, sewage." (*Ib.*)

Presence of nitrites may be tested for by Preusse and Tiermann's process, observing colour developed in, say, 100 cubic centimetres of water under examination on the addition of 1 c.c. of a solution of meta-phenylenediamine and 1 of dilute sulphuric acid.

Chlorides may be tested for by adding some silver nitrate to the water, when a white precipitate (silver chloride) will come down. Surface water from marshy soil is particularly to be avoided, being charged with organic matter, and occasionally with a specific micro-organism, *Bacillus Malariæ*—said by Klebs and others to be the specific germ of ague fever.

3. Next we come to consider the water supply obtained from rivers. It is held that water derived from this source is usually good. There are, however, many objections to river

water, amongst which I would mention local contamination, either normal or unexpected, such as outbreak of any infectious disease in towns situated on the bank of such river.

To those of my readers who care to see what pollutions rivers are exposed to, and how they are legally defended from such pollution, I would commend—Public Health Water Act, 1878; River Pollution Act, 1876.

4. The best source of water supply is a deep well.

In sinking a well, the least depth which I think one ought to bore is fifty feet. At all events, the perforation should extend through some such impermeable stratum as rock or thick clay.

Specimens of water from different strata partake more or less of the characters of the stratum from which each specimen has come.

A clayey stratum affects water very little, but forms an excellent safeguard against external contamination.

Water from the strata of sand or gravel is pure, though more liable to contamination than the last-mentioned specimen. Both the above are comparatively soft waters.

Strata in which chalk and dolomite preponderate yield hard water. If that hardness—temporary—is, however, due to calcium carbonate, it can be mainly removed by boiling. If, however, the hardness—permanent—is due to more stable salts of lime, it cannot be so got rid of.

5. *Public Water Supply.*—Useful information on this subject may be gained from a perusal of "Waterworks' Clauses Acts, 1847 and 1863. The following is culled from the "Practitioners' Index:"—

"It is presumable (though, unfortunately, the presumption is not always justified) that water supplied for the public is fit for use as a beverage. In many towns (it may almost be said, in most of them) it should be filtered before it is imbibed.

"When the delivery is intermittent, water so supplied is received into cisterns, from which it is drawn off as required. These cisterns often are, but never should be, the same as

those used for the water-closets, the water in which is almost sure to be contaminated by the sewer gases ascending from the basin through the flushing pipe.

"Town water cisterns, like those used for the storage of rain water, need periodic cleansing, though generally at much less frequent intervals."

The symptoms which, in conjunction with absence of positive knowledge that the water supply on which we trust is above suspicion, should lead us to fear contamination, may be briefly summed up as follows:—

(*a*) Diarrhœa,
Dysentery,
Typhoid (gastric) fever—
indicate that water contaminated by decomposing organic matter, or septic germs (e.g. sewage-contaminated water) having had access to the interior of the digestive tract.

(*b*) Goitre—
indicates water rendered unwholesome by lime and magnesian salts.

(*c*) Colic—
indicates water contaminated by being stored in lead cisterns. With regard to class (*c*) of impurities, the following remarks may be found useful.

The bright surface of recently cut lead will remain untarnished in absolutely dry air, but the moment moisture touches it, the surface becomes dull owing to the oxidation of the metal—this oxidation proceeds rapidly in presence of a small quantity of weak acid—e.g. CO_2.

In water absolutely free from air, lead also preserves its lustre, but if air be present, lead oxide is formed, and, this dissolving slightly in the water, a fresh portion of the metal is exposed for oxidation.

Also, waters containing nitrates and chlorides are liable to contamination with lead, and should not be stored in reservoirs of that metal.

If lead contamination is suspected, it may be chemically tested for, by passing a stream of SH_2 through a specimen of the water, having first added a little weak acid. If lead is present, a brown deposit will be observed in the liquid.

Lead contamination may be prevented by either of the following methods :—

1. By coating the inside of such pipes or cisterns with the sulphide of lead, which is insoluble in water.

2. Saturating water with carbonic acid, and passing the solution through the pipes or cisterns, thus forming a coating of lead carbonate in the pipes or cisterns.

As to other impurities, and how to detect them, I might enumerate many, and attempt to elucidate the technical tests here-for, but I fear it would be wearying, and perhaps only confusing, to my readers. I will, therefore, close my consideration of water supply by appending the following quotation from "Our Homes" by Shirley F. Murphy :—

"The best way of estimating, for the general public, is to attend "to the physical character of the water, embracing the following "chief points.

"1. The water must be clear, and entirely free from sediment or "suspended matter.

"2. Colourless, or bluish, if looked at through a depth of two or "three feet. Greenish waters are not generally hurtful. Yellowish "or brownish waters are to be suspected, unless the colour is known "to depend on peat or iron.

"3. Should be bright and sparkling, showing that it is well "charged with air and CO_2.

"4. Should have pleasant taste of good water, but no brackish "or other unpleasant taste.

"5. Should have no smell.

"Should be soft to the touch, and dissolve soap easily."

Before dismissing the purely sanitary part of my subject I would append a brief list (condensed from Kimpton's "Medical Annual") of common symptons, both pathological and physical, which should lead us to suspect defective drainage.

It will be my endeavour to avoid all medical terms as far as possible, and to indicate what I mean in plain language.

Common pathological symptoms may be classed as under :—

Affections of throat—simple or ulcerated,
Enlargement of tonsils and uvula,
Furred tongue with attendant evils,
Headache—suppose "biliousness,"
Typhoid fever,
Erysipelas { if patient was previously suffering from any "open" sores, or if the foul air had access to recent wounds—e.g. after child-birth.
Diarrhœa,
Diphtheria,
Puerperal fever—see above, "Erysipelas,"
Pyæmia, „ „
Septicœmia, „ „

["The question of identity of 'puerperal fever' and "'septicœmia' is largely one of definition." (Lusk's "Science and Art of Midwifery," p. 609).]

Common physical symptoms may be classed as under :—

1. Faint or foul odours in or about a house, not proceeding from any evident superficial source. These are often perceived only on coming in from the open air. However slight, they should suggest immediate inquiry.

2. Damp places in walls and pavements, along or near the course of a drain.

3. Subsidence of floors over the line of a drain.

4. Chokage of sinks or water-closets.

5. Rat-holes in or near the basement of a house.

Sewer-gases are likely to enter a house the most freely, and to produce the most baneful effects in winter, when doors and windows are closed, and fires are burning.

Deodorants, Antiseptics, and Disinfectants.

There is much looseness in the use of these terms.

(*a*) *Deodorants* remove bad smells; and some of them do no more. Others are also antiseptics or disinfectants. The chief deodorants are,—

1. Charcoal
2. Earth

} acting principally as absorbents and oxydizers.

3. Chlorine gas
4. Ozone
5. Permanganate of potassium

} acting by virtue of their oxydizing power.

6. Nitrate of lead fixes the sulphur of sulphuretted hydrogen, thereby destroying the offensive smell.

7. Sulphate of copper
8. „ of iron
9. „ of zinc
10. Chloride of zinc
11. Perchloride of iron

} in solution, act similarly, and also remove ammoniacal odours.

(*b*) ***Antiseptics*** check or wholly prevent decomposition.

The principal antiseptics, generally applicable, are,—

1. Carbolic acid.
2. Sulphurous acid.
3. Alum.
4. "Chloralum."
5. Sulphate of copper.
6. Sulphate of iron.

(*c*) ***Disinfectants*** exert a destructive action upon minute living organisms, and upon dead organic matter.

The most available disinfectants are—

1. Chlorine.
2. Ozone.
3. The permanganates.

All soils possess, to a greater or less degree, the property of purifying sewage. Clay soils have a much greater affinity for fertilizing matter than sandy soils; nevertheless heavy clays are too impervious for sanitary purposes.

Quicklime, applied to *fresh* animal matter, prevents smells; but if fermentation has already set in, the first effect is to set free the ammonia and other strong-smelling volatile alkaline compounds, and, afterward, to retard further decomposition, and to make the changed volatile compounds less disagreeable to the sense of smell, and less injurious to health.

Chloride of lime, spread in the solid form upon any fermenting mass, destroys the noxious bodies as they are formed. Dissolved in water, and sprinkled over bad-smelling chambers, or mixed with fluid collections of putrid matter, it brings sweetness everywhere. Its own odour is, however, offensive to many persons.

Chloride of zinc (Burnett's disinfecting fluid) is also very effective.

Sulphate of iron can be used with the best results Dissolved in water, it gives a very acid liquid, which can be handled without danger, and can be used to wash infected places or animals, or to mix with excreta infected with disease. It assists in decomposing the sulphuretted hydrogen. It may, with advantage, be mixed with *sulphate of copper* (blue stone) in the proportion of four parts of the former to one part of the latter.

Permanganate of potash[1] is a powerful ozonizer. A very small quantity sprinkled on a towel, and waved to and fro in a sick-room, or distributed by a small syringe, will deodorize and purify the air of the room like magic, without substituting any other odour.

M'Dougal's fluid for disinfecting sewers contains two pounds of sulphurous acid for every ounce of carbolic acid. This quantity is considered sufficient to deodorize the excreta of 300 persons for one day.

Carbolic acid, "*chloralum*," *sulphate of copper*, *alum*, *Cooper's salts*, or *Dr. Goolden's disinfectant*, are very efficacious when thrown down a sink, drain, or water-closet, or over a heap of decaying rubbish.

But the use of these substances is legitimate only as a temporary expedient, and in cases where there is no other remedy.

[1] A useful form of this disinfectant is found in the "Porous disinfector" (Sharp and Co.). It consists of a porous cell which contains crystals: this cell is placed in the closet cistern, and continues to disinfect the water for about eighteen months, when the contents of the cell can be renewed.

The desirable course is to prevent or remove the conditions which suggest a resort to them.

Before leaving the subject of disinfectants, antiseptics, and so forth, I should like to say a few words on an allied subject—the propagation of a certain class of infectious diseases.

There is a set of what have been termed "preventible diseases," amongst which I may mention, as most common, cholera, some forms of diarrhœa, and typhoid fever. These diseases have been termed also "filth-diseases," from the fact that they are propagated by *excreta*, in some form or other, coming in contact with the interior of the animal organism. Unquestionably it is an unpleasant admission, but still equally unquestionably it is true, that these diseases are "caught" either by inhaling from the air we breathe, or by swallowing in the water which we drink, infinitesimal particles of fœcal matter, i.e. sewage.

As typhoid—or enteric—fever is unfortunately a very common disease amougst us, I shall take it as a type of these "filth-diseases," and shall endeavour to explain, in popular language, the mode of origin and propagation of this disease.

Typhoid fever is capable of being communicated to the healthy from the sick; it is not contagious; but it is, in a peculiar manner, infectious; by this I mean, it is not necessarily dangerous to those around the patient, nor can they, in their turn "infect" others, whom they may subsequently meet, as is the case with many other forms of disease. Sir William Jenner, writing on this subject, says, "I have never known a "case, removed from its place of origin, spread to the inmates "of the house into which the patient was removed, *unless* there "were some communication between the source of the drinking "fluid and the excreta of the patient," e.g. faulty sanitary arrangements (see System I., "*Cisterns*").

Typhoid fever has its own *virus*, or specific germ-poison. This germ-poison, or seed, is taken into the animal organism,

and it there flourishes, reproducing itself in a marvellous manner, and in a very short time the poison has taken such complete hold of the patient's constitution as to be very difficult of (and often baffling) eradication. It will easily be understood that, when this original germ has thus reproduced itself, in a patient, his *excreta* will literally teem with fresh germs, for it must be borne in mind that typhoid fever attacks the intestine with especial vigour.

It is from the *excreta*, then, of patients, prostrate with this disease, that we must expect future danger to arise. These discharges contain the poison, and it is impossible to evince too great care in *at once* "disinfecting" all *excreta*, while fresh, before ejecting them from the precincts of the house. It is, too, during an epidemic of this nature that we realize the incalculable advantage of a perfect system of house sanitation.

In case the above statements may be at variance with the views of some of my readers, and for fear that they should therefore think I am making "one-sided" statements, it may be as well to state the following:—

There are two main views about the propagation of this form of disease; some hold that each case of typhoid fever must have had a "parent case," from which to originate; others, on the other hand, affirm that the *virus*, or specific germ, may have an independent origin, that is to say, that foul matter (e.g. sewage) by undergoing certain fermentative changes, will cause typhoid fever, independently of any previous case of the disease.

So much, then, for the consideration of the part of my subject which I have termed "Sanitation Major." It has been my endeavour to offer a few suggestions to my readers in order to enable them to know at least where to expect insanitary danger at all times, but it must be left to each individual whether or no he will meet cholera, should it visit us, forewarned and so forearmed. I will now devote a few pages to the discussion of what I have termed "Sanitation Minor"—in

other words, subjects which, though of less vital importance than those of which I have already treated, should yet receive no small share of attention if we wish to retain our health and vigour.

PART II. "SANITATION MINOR."

VENTILATION OF THE DWELLING-ROOMS.

HAVING considered what I hold to be the most important factor in a healthy house, it may not be out of place now to notice briefly a few points, by attention to which we may avoid all those minor ills which flesh is heir to. Minor ills such as headache, lassitude, diminution of mental and bodily energy, which often assail us when we are sitting quietly in our rooms in the evening, and which, though perhaps of no very great consequence in themselves, yet tend, like the constant dripping of water on the rock, to undermine the strongest constitution.

All these minor discomforts should—and, I think, I may say would—be strangers to us, if we only paid a little attention to the state of the atmosphere in our rooms, or, in other words, supplied a little "ventilation."

Let us consider for a moment what ventilation, as applied to our rooms, means; for our purpose we may define it to be—

> "The art of removing the air which, by the presence of animal life and by the products of combustion, has been rendered vitiated, combined with the art of introducing fresh air without inconvenience to the inmates of the room."

Now, of course, we cannot expect the air in our rooms to be as pure and sweet as the—

"Balmy breezes of June's early morn,"

but we may assume that any apartment which strikes us as close or "stuffy," when we enter it, is unfit for our habitation, and requires our serious attention with respect to the ventilation thereof.

From our above definition we see there are two things which it is necessary for us to do:—

1. To remove the vitiated air, and
2. To supply fresh air.

"Supply" and "removal" must be considered together, for it is an obvious fact that if fresh air could be supplied to any room without other air being removed, we should be constructing a kind of "air condenser;" in fact, increasing the pressure of the air inside the compartment.

So, on the other hand, if we could remove the vitiated air without allowing entrance to the fresh, we should be converting our room into an "air pump," and should ultimately produce a "vacuum," which, as we all know, "nature abhors."

We have, then, first to decide how we can most efficiently get rid of the vitiated air—that is, at what point or points our "outlets" shall be placed to allow the readiest escape of foul air; and, secondly, our "inlets" must be so arranged that the supply of fresh air shall neither be too abundant, nor enter at wrong places and in wrong directions. A quantity of fresh air let in at random will only produce uncomfortable currents all over the room, and we must therefore have some simple rules to guide us both as to "quantity" and "place of ingress."

I shall show you no elaborate scheme of house ventilation, but shall endeavour to explain how *existing rooms* may be made healthy and comfortable with the least possible trouble and expense, for I think that the very ponderous elaboration

of the schemes for house ventilation which have, from time to time, been placed before the public, both by authors, and by manufacturers of ventilating appliances, has tended, perhaps, more than anything else, to deter the public from attempts at ventilation.

In considering the quantity of fresh air which must be supplied to any apartment, to render it fit for habitation, we must consider first how the air in that apartment is going to be used both by human beings and by combustion of gas, lamp, or other illuminating agent. A man of average height takes into and expels from his chest, at every "breath," 500 cubic centimetres (say 30 cubic inches) of air.

Now, as we shall presently see, the relative percentage compositions of inspired (pure) and expired (vitiated) air differ considerably.

The incoming air, which, for the sake of argument we will assume to be "fresh air," has the following percentage volumetric composition.

Oxygen	20·96 per cent.,	say, 21 per cent.
Nitrogen	79·02 „	„ 79 „
Carbon dioxide...	varies,	„ 4 per 10,000

There is a certain amount of moisture in the atmosphere as well, but it is a very varying constituent indeed, the quantity present, depending, of course, on the temperature; so that air with a given amount of moisture contained may appear dry or moist, as the temperature rises or falls; but for our purpose the atmosphere is considered to be "dry" (i.e. very far from "saturation point").

When we come to consider the expired air we find that a considerable modification of the original percentage composition has taken place; roughly speaking, 5 per cent. of oxygen has disappeared, while the amount of carbon dioxide has been increased to 4 per cent., as will be seen from the annexed rough table:—

	Inspired air.	Expired air.
Oxygen	21 per cent.	16 per cent.
Nitrogen	79 „	79 „
Carbon dioxide... ...	4 parts per 10,000	4 „

Nor are these the only differences between inspired and expired air, though they are those which concern our subject, perhaps, most nearly; still I will mention that the temperature of the expired air is usually increased [1] (see foot-note), and, moreover, that the moisture contained in expired air is considerably increased, expired air leaving the body (in healthy and ordinary respiration) at (or very near) "saturation point."

"It must be remembered that the air, when warm, is capable of holding a greater quantity of vapour than when it was inspired. The difference can best be appreciated in cold weather, when the vapour of the warm expired air is condensed on meeting the cold atmosphere." (G. F. Yeo, Esq., M.D, F.R.C.S.)

In order to give my readers a clearer idea of the exact meaning of this "condensation," I will quote the following from Professor Loomis' "Treatise on Meteorology."

"When steam (i.e. the vapour of water) rises from a vessel and mingles with a cold atmosphere, a portion of the vapour is condensed and a mist is formed. This mist is sometimes, but improperly, called vapour. *Vapour of water* is an invisible gaseous body, while *mist* is a liquid body."

"The expired air is also said to contain traces of the following impurities: ammonia, hydrogen, carburetted hydrogen, and organic matter. These, and probably other, impurities give the breath its peculiar odour and noxious properties, for an atmosphere rendered 'stuffy' by expired air

[1] Temperature of atmosphere .and of expired air.

− 6·3° Centigrade	=	+ 29·8° C.
+ 17·0° „	=	+ 36·2° C.
+ 44·0° „	=	+ 38·5° C.

"Manual of Physiology," by G. F. Yeo, M.D., F.R.C.S.

is much more injurious to health than an atmosphere in which a similar deficiency of oxygen or excess of carbon dioxide has been produced by chemical means." . . . "The following table may assist in comparing the atmosphere with the expired air" (Dr. Yeo):—

	Atmosphere.	Expired air.	Difference.
Carbon dioxide.	·04 per cent.	4·38 per cent.	+ 4·34
Oxygen . .	20·81 „	16·03 „	— 4·78
Nitrogen . .	79·15 „	79·55 „	+ ·40
Temperature .	—6°C to +35°C	29·8° C. to 38·5° C.	
Moisture. . .	about 10 grms. to 1 cubic metre.	about 40 grms. to 1 cubic metre.	
Volume . . .	. . . .	apparently increased, absolutely diminished $\frac{1}{30}$th.	
Impurities . .	. . . .	Ammonia, hydrogen, carburetted hydrogen, and poisonous organic matter.	

So much, then, for the various impurities which must abound in our rooms, unless ventilation is adequately attended to.

This carbon dioxide, *per se*, as I have shown above, is not a very important impurity if it were itself a pure sample of that gas, but unfortunately it has been found to exist (in expired air) in a constant ratio with the more deadly organic impurities above mentioned. So, therefore, as it is tolerably easy to estimate the amount of this gas in a given sample of air, the percentage of carbon dioxide present may be taken as an exponent of the impurity of such sample.

About 20 cubic centimetres of carbon dioxide (4 per cent.,[2] of 500 cubic centimetres—*vide* table of inspired and expired

[2] I have taken round numbers (i.e. 4 per cent. instead of 4·38 per cent.) so as to indicate easily, for those of my readers who care to follow the calculations, the *raison-d'être* of the estimates.

air—or 4 per cent. of 30 cubic inches, say $1\frac{1}{5}$ cubic inch) are given off at each "breath," and, taking the average of 17 "breaths" per minute, we get—

In cubic centimetres,

$20 \times 17 = 340$, as amount of CO_2 evolved per minute,
or, $340 \times 60 = 20{,}400$ „ „ per hour.

In cubic inches,

$1\frac{1}{5} \times 17 = 20{\cdot}4$, as amount of CO_2 evolved per minute,
$20{\cdot}4 \times 60 = 1200$ „ „ per hour.

Dr. M. Foster, in his text book of physiology, says: "Taking, as we have done, 500 cubic centimetres, as the amount of air passing in and out of the chest, a person will expire about 22 cubic centimetres of carbonic acid at each breath; this, reckoning the rate of breathing at 17 a minute, would give 500 litres of carbonic acid for the day's production."

Pettenkofer and Voit, however, give 800 grms. (406 litres); this amount includes the excretion of carbon dioxide from the skin (10 grms.).

Pettenkofer gives some interesting details as to the amount of carbon dioxide given off in relation to the weight of the individual both when at work and at rest (estimated per hour):—

Weight of subject.	CO_2 evolved at *night.*	During *moderate work.*	*Hard work.*
132 lbs.	0·56 cub. ft.	0·78 cub. ft.	1·52 cub. ft.

From these data, convenient formulæ, for determining the normal amount of CO_2 to be looked for, can be deduced. Thus—

At rest ... ... ·004 cubic feet per 1 lb. of subject's weight.
Moderate work ·005 „ „ „
Hard work ... ·012 „ „ „

It is worthy of note that the above figures are almost in the

ratio of 2 : 3 : 6, which is a sufficiently accurate estimate for all practical purposes.

From this formula it is very easy to calculate the amount of carbon dioxide which will be given off by any person; and, as a still further rough guide, it may be stated that—

An "average" male weighs (for "ventilation purposes") 12 stone = 168 lbs.

An "average" female weighs (for "ventilation purposes") 9 stone = 126 lbs.

A child weighs (for "ventilation purposes") 8 stone = 112 lbs.

With regard to children, it should be borne in mind that, both from the hypothetical reason that their tender years render them less able to withstand the effect of vitiated air, and also from the fact that physiological changes are very actively going on in their tissues, an estimate in excess of that given above should be made in all schemes of ventilation for buildings where children are likely to be congregated together. If we accept the percentage of carbon dioxide found in the air of any room as a measure of the vitiation of that air, we must then make up our minds what degree of purity we desire, or rather, what degree of impurity we are willing to put up with.

An atmosphere in which the carbonic acid has been raised to 1· per cent. by respiration is highly injurious. In fact, air rendered so far impure by breathing that the carbonic acid amounts to ·08 per cent. is distinctly unwholesome.

There must, of course, be some impurity in the air of our dwelling-rooms—absolute purity of air being hardly obtainable unless in the open air. This, I think, is conclusively demonstrated by the following, culled from a paper by Dr. De Chaumont, which appeared in the *Edinburgh Medical Journal*, May, 1867 :—

"The carbonic acid in the air being taken at four parts per 10,000, and the carbonic acid of respiration being estimated at ·6 cubic feet per hour, a man placed in a room of 1000 cubic feet of air must receive not less than 1,000,000 cubic

feet of outside air in an hour to reduce the carbonic acid to the standard of the fresh air."

Fortunately nature has provided us all with a ready means of ascertaining fairly accurately whether the air in our rooms is fit for respiration or not. If on coming in directly from the fresh air we perceive an unpleasant "stuffiness" in the air of our rooms, it may be taken for granted that the degree of impurity of such air has passed the limit.

It is a fact well worthy of notice that the animal organism ceases to take cognizance of the impurity of the air breathed, if subjected to an atmosphere the carbon dioxide tension of which is gradually increasing with corresponding decrease of oxygen tension. This is well shown by the experiment of placing a sparrow under a bell-jar into which no fresh air is admitted—the creature will continue to live for some considerable time; but if a second sparrow is then made to breathe the same atmosphere, the result is almost immediately fatal to the last-comer.

By this it is not of course intended to convey the idea that the animal economy can be "educated" to live without oxygen, but merely that, within limits, the respiratory functions can, by gradual exposure to an almost imperceptibly increasing vitiation of the air breathed, be so modified as to give place to a gradual "decay of vitality" of perception, which will ultimately result in total cessation of the vitality of the individual.

As a further proof, however, of the capability of the animal (and in this case human) economy for "education" in withstanding the effects of breathing impure air I will mention the following:—

About a year ago, I was consulted with regard to the ventilation of one of our most popular London theatres. I visited it on very many occasions, and took the temperature, &c., of the various parts of the theatre, both auditorium and stage; on each occasion of my visiting the upper part of the theatre, I was struck with the comparatively low temperature, and at the same time the feeling of excessive oppression.

Coming, on each occasion, from the relatively "fresh" corridors, it was always a marvel to me how people could sit in such a —to me—terrible atmosphere. They had arrived early in the evening, when the air was comparatively pure, and had so got acclimatized, I suppose, to the gradually increasing vitiation.

On one occasion I determined to go early to that part of the theatre and to sit the performance out. When I took my place the air was comparatively pure and the temperature moderate. After I had been there about an hour a feeling of great lassitude and oppression came over me, resulting finally in headache. I then went out for some fresh air, and on returning could not make up my mind to remain. On taking the temperature I was somewhat surprised that there was by no means the increase which I had anticipated.

That excessive temperature is, in no case, a criterion of the standard of impurity is well instanced, I think, in the familiar Turkish bath.

Hence the only reliable practical test of impurity of air in any room is that the apartment in question feels oppressive and "stuffy" to a person coming direct from the outside air.

The following table, compiled from observations by Dr. De Chaumont, will, I think, give my readers a clear insight into the detection of impurity of inspired air:—

	1. Fresh, or not differing sensibly from outer air.	2. Rather close; organic matter becoming perceptible.	3. Close; organic matter disagreeable.	4. Very close; organic matter offensive and oppressive. Limit of differentiation by the senses.
Mean carbon dioxide per 1000 vols. (reduced to 32° F.) due to respiratory impurity.	0·1943	0·4132	0·6708	0·9054

From this table it will be seen that the organic matter is perceptible to the sense of smell when the carbonic acid of respiration exceeds 0·1943 per thousand; ·2 per thousand may therefore be taken as the limit of impurity to be allowed in dwelling-rooms.

Having, then, ascertained the limit of impurity, we must now fix upon the quantity of fresh air which must be supplied to a room in order to keep the vitiation at or below this standard.

As we have seen (p. 78) an adult man evolves rather more than half a cubic foot (1200 cubic inches), "·6 cubic feet; (Parkes), per hour, and therefore in that time he vitiates "more than 1000 cubic feet of air by raising the percentage of carbonic acid [3] to ·1 (·04 being initial, and ·06 respiratory)," (Yeo). Of course, the smaller the dwelling-room is, the more rapidly will the air therein become vitiated by respiration; it is therefore necessary to have not only a definite breathing-space, together with a certain supply of air for each inhabitant, but the space and supply must bear a certain ratio to one another, in order to keep up the requisite purity.

The following table, extracted from "Parkes' Manual of Hygiene," gives such relative quantities :—

Amount of breathing, space for one man.	Ratio of carbon dioxide per 1000, from respiration, at end of one hour if there has been no change of air.	Amount of air necessary to dilute to standard of ·2 during first hour.	Amount necessary to dilute to standard every hour after the first.
100 cub. ft.	6·00	2900	3000
200 „ „	3·00	2800	3000
300 „ „	2·00	2700	3000
400 „ „	1·50	2600	3000
500 „ „	1·20	2500	3000
600 „ „	1·00	2400	3000
700 „ „	0·86	2300	3000
800 „ „	0·75	2200	3000
900 „ „	0·67	2100	3000
1000 „ „	0·60	2000	3000

[3] I have taken in *my* calculation ·02 as initial, instead of ·04.

The following formula will give the amount of fresh air required in any case:—

c = amount of carbon dioxide evolved from any one person per hour.

l = limit of impurity allowed per 1000 cubic feet.

x = required amount of fresh air (thousands of cubic feet).

Then $\frac{c}{l} = x$.

e. g. $\frac{0{\cdot}6}{0{\cdot}2} = 3$

Therefore, with a discharge of ·6 cubic feet of carbon dioxide per hour, 3000 cubic feet of fresh air must be supplied to dilute the air to the required standard (see table, p. 82).

Hitherto we have only considered the effect of respiration and transpiration on the air of our rooms. We have, however another important factor to deal with.

That is to say, the products of combustion proceeding from the illuminating agent employed, which may be either gas, oil-lamp, or candles.[4]

Gas is not a mere chemical compound, but is the resulting product of a mixture of several compounds.

To obtain gas, "cannel," or some highly bitumenized coal, is placed in a closed "retort" and heated, the result of which process is the formation of the following volatile products: tar, ammonia, vapour, and "gas," whilst the carbon remains behind in the retort.

The gas is usually purified before being supplied for illuminating purposes, and best "cannel gas" may be taken to possess the following percentage composition:—

Hydrogen.	Marsh gas.	"Heavy" hydrocarbons.	Carbonic oxide.	Nitrogen, oxygen carbonic acid.
25	51	13	8	2 to 3

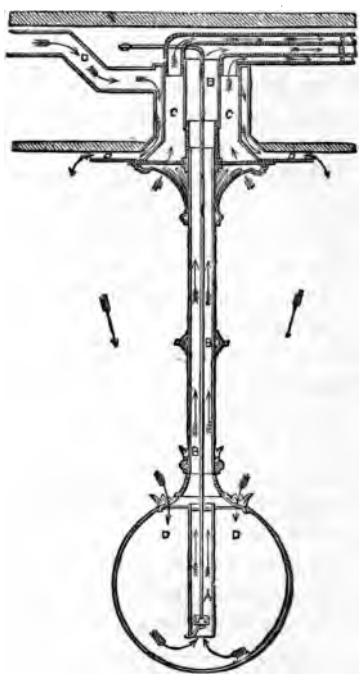
The illuminating power is estimated by comparing the light

[4] I do not deal with electric light, for obvious reasons.

produced by the gas burning at a certain rate (viz. five cubic feet per hour) with that given out by a sperm candle burning 120 grains per hour. It is found to be equal to about thirty-four (rather more) candles.

It will be seen from the following considerations that gas is much more greedy of oxygen than a human being, for one

A.



B.

cubic foot will entirely consume the oxygen of eight cubic feet of air. Gas, moreover, as we all well know, raises the temperature of our rooms very considerably. Roughly speaking, each cubic *foot of gas burnt* per hour may be taken to vitiate as much air as would be rendered foul by the respiration and transpiration of a human being, and when we know

the amount of gas consumed by a given burner in an hour, we can make an estimate for the supply of fresh air. It must, moreover, be remembered that gas tends to render the air abnormally dry, as is well instanced in the case of engravers' work-rooms, where it is found necessary to keep water constantly in the room. It is no uncommon thing to find an engraver working with a wet sponge in close proximity to his nose.

If then the products of combustion of gas are allowed to pass into the room, an extra supply of fresh air should be arranged for. (The amount of this can easily be calculated from the previous remarks, and by reference to table.)

"Wolpert has calculated that for every cubic foot of gas 1800 cubic feet must be introduced to dilute properly the products of combustion.

"A common small gas burner will burn nearly three feet per hour, and will consume ten or twelve cubic feet in an evening (four hours), and therefore from 18,000 to 21,000 cubic feet of air must be introduced for this purpose alone in the four hours, unless the products of combustion are removed by a special channel" (Parkes' "Hygiene").

The subjoined illustrations show a ventilating gas-globe (A. elevation), (B. section) which heats the room but little, and does not vitiate the air in the least. It draws its air supply from the external air, and discharges the products of combustion into the chimney.

The complete combustion of one pound of oil requires about 140 cubic feet of air, and if the air of the room is to be kept perfectly pure, as much air must be supplied as would suffice for the combustion of ten feet of gas.

If candles or oil-lamps are used in a room, it is scarcely necessary to take them into account in estimating the supply of fresh air.

The conclusions to which an eminent architect (Ernest Turner, Esq., F.R.I.B.A.) comes on the relative merits of candle, lamp, and gas, are the following:—

"The most abundant, cheapest, and—light for light—

coolest illuminating agent is gas. It is commonly supposed to give out more heat than any other. But this, like most popular ideas, is a delusion.

"Those who burn gas get their rooms more heated than those who burn candles, but that is because they get twenty times more light, and, in fact, must have it; because gas cannot be wholesomely burned at a very low pressure."

We have now considered, at some length, the various factors which take part in the vitiation of the air in our rooms, and have also discussed their *modus operandi*, let us briefly recapitulate.

For each human being 3600 cubic ft. of air per hour (say one cubic ft. per second)
For each gas-burner 3600 cubic ft. per ft. of gas burnt per hour
For each sperm candle 1200 cubic ft. per hour
For each oil-lamp 3000 cubic ft. per hour
} are required.

Now that we know what we have got to do in the way of supplying fresh air, it becomes a simple matter of expediency and expense whether we ventilate our rooms or not.

Of course it is expedient, and I hope I shall be able to demonstrate that it is not very expensive either. As I have previously indicated, fresh air cannot be admitted unless a corresponding amount of foul air is also extracted, and I may as well state that, for all practical purposes, the area of inlet and outlet may be the same, as I do not propose to take my readers into the increase of volumes of gases according to increment of temperature.

A suitable aperture to admit the amount of air necessary for one person is 6 × 4 inches.
A suitable aperture to admit the amount of air necessary for two people is 6 × 8 inches.

Every additional 1000 feet requiring an additional opening, whose area is eight square inches.

Now let us see what are the usual means in an "unventilated" room whereby this amount of fresh air finds entrance; an infinitesimal amount diffuses in through the walls, but by

far the greater quantity finds an unwelcome entrance through the cracks and crevices which abound in and about our doors and window-frames, causing those horrible draughts with which all of us are only too familiar in cold and tempestuous weather. These draughts are the only means which exist in an unventilated room for procuring two important results; first, sufficient air for us to breathe, and secondly, sufficient air to feed the fire and to regulate the chimney draught; the latter may often be brought to a standstill, or, worse, reversed (causing a "down-draught"—that dreaded nuisance, a smoky chimney), if these draughts are prevented by abominations known as "sand-bags."

As we shall see later on, one of the most frequent causes of a smoky chimney is an insufficient supply of fresh air.

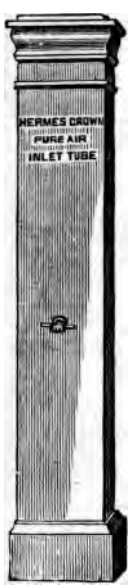


Fig. 25.

We have now to consider how the requisite supply of fresh air can best be effected, by means of ventilation.

The great aim in introducing fresh air into a room should be to introduce just as much as is required for thorough ventilation and chimney draught; the "natural" currents in the room should first clearly be made out, and it should be our endeavour to assist these as much as possible; it is almost impossible to lay down fixed laws as to where and how air should be admitted, as this must depend on the construction of the room.

Speaking generally, the following rules should be adhered to where possible.

Fig. 26.

(i.) The air should be admitted through some contrivance y which "draught" will be prevented.

Amongst the many contrivances, artistic and otherwise, which have been devised to act as inlets I may mention,—

"Air-inlet tubes" (figs. 25 and 26). These consist of vertical tubes, fitted with straining-bag (to retain impurities), to which also can be appended, if desired, a "moist tray" or some air-warming apparatus.

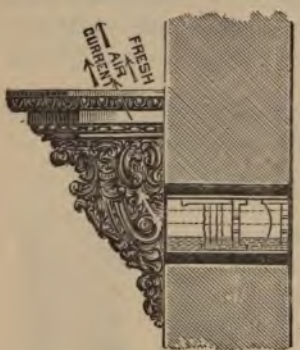


Fig. 27.

Fig. 28.

"Air-inlet brackets" (fig. 27), ornamental contrivances, to attain the same object as the tubes. (Sharp and Co.)

Louvre ventilators (fig. 28) may be used over doors or in walls.

Circular ventilators (fig. 29), which work on a screw, and can be opened or closed at will. (Comyn Ching and Co).

Fig. 29.

(ii.) The apertures for admitting air should be arranged so as to diffuse the incoming current as much as possible.

(iii.) They should be far removed from persons in the room.

Air may be introduced from the back of the grate, and, there being warmed, is led through a separate

chamber to an inlet just below the ceiling, whence it can be projected into the room. This, however, entails a certain amount of disturbance of existing arrangements, and is, therefore, not to be very highly commended from one point of view.

The proper position for outlets is very seldom understood. In rooms with fire-places having no tendency to smoke, and with a good up-current in the flue, the outlet ventilator should be in the chimney breast (figs. 30 and 31). This arrangement shown below is very frequently resorted to. The ventilator can be fixed at a minimum of expense. A far better means, however, of providing an outlet for the vitiated air (and one which prevents the decoration of the room being spoilt by the insertion of an unsightly grating in the wall) is to fix in the chimney breast a perforated cornice, with the old-fashioned

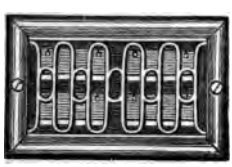


Fig. 30.

Fig. 31.

valve grating behind; this answers the purpose best, and cannot offend the most æsthetic eye. In the same way, when it is necessary to make openings (on Sheringham's principle) in outside walls, gratings can be hidden behind perforated cornices, care being taken to provide means for cleaning from outside.

In many houses, special air-flues, or exhaust shafts, are provided for the extraction of vitiated air from the rooms. Commencing (usually) behind a perforated cornice, these lead to some point clear of the roof, and terminate after the manner of a smoke flue.

It is often found desirable to surmount the upper extremity of such shafts with some aspirating cowl or ventilator, in order to accelerate the upward current, and to prevent "blow-down."

If these pipes terminate in conspicuous places, an ornamental design of ventilator (similar to Figs. 32 or 33) might, with advantage be used.

Both inlets and outlets should always be constructed in such a way as not to be noticeable, either by their ugly appearance or the too forcible passage of air currents through them.

In conclusion, if we rely solely upon the fireplace as an outlet for the removal of foul air, then, on account of the low

Fig. 32.

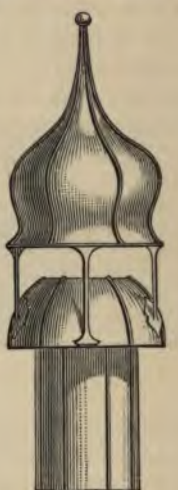


Fig. 33.

level of the extracting area, "only cats, dogs, and children hardly higher than the table could breathe fresh air in the room" (Ernest Turner).

Before dismissing my subject entirely, I think a few words on a point which, though, perhaps, not strictly a sanitary one, yet is on the border-land between "Sanitation," in its highest sense, and comfort, will not be out of place.

I take it that to attain the highest form of sanitation each must possess a "*mens sana in corpore sano.*" Therefore, I

think that anything which tends to personal comfort decidedly promotes that equanimity, and conversely that which tends to personal discomfort militates against it.

Assuredly no domestic derangement so disturbs that equanimity as much as does our old foe, a smoky chimney, and I shall devote the remainder of this little work to the consideration of some of the reasons why chimneys "smoke," indicating at the same time a cure in each case.

PART III.

SMOKY CHIMNEYS, THEIR CAUSES AND CURE.

BEFORE concerning ourselves with artificial means and remedies, we will just glance at the natural agencies by which a draught up a chimney is produced.

The main forces upon which we depend for the performance of this domestic function may be classified as under :—

1. The *vis a tergo* forcing the air from our rooms, i.e. plentiful supply of fresh air, which, when heated, rises.

2. The *vis a fronte*—the suction power exerted by the wind passing over the tops of our chimneys, which causes a vertical draught up the chimney at right angles (more or less) to the direction of the wind.

1. Under the first head we have the movements of the atmosphere, caused by the difference in weight of particles of air at different temperatures.

It is, of course, an established fact that when the air in a room becomes heated, it expands and rises, and endeavours to escape; if there be any exit, part of it will find egress, and that which remains will be lighter than an equal bulk of air external to the compartment.

The external air will then rush into the room, by every chink and crevice, until equilibrium is established, the colder (external) air pressing the warmer air upwards and occupying its former place. The rate at which the warmer air is thus pressed upwards by the incoming current, and finds egress, must depend on (*a*) the difference in temperature between the incoming and outgoing air, (*b*) the area of the outlets, (*c*) the frictional resistance of the shaft (chimney), and (*d*)

upon the height of the column of ascending (warmed) air. A simple way of demonstrating the interchange of gases between a room in which a fire is burning and an adjoining cold room is the following:—

If the door between the two rooms be held open, and a lighted candle be placed on the ground near the door, the flame will be blown inwards (i.e. towards the room in which is the fire); if the candle be held about six feet from the ground, the flame of the candle will be blown the reverse way. "A velocity of one and a half feet per minute will bend the flame 45°" ("Tomlinson," p. 221).

The conditions upon which we rely for the advantageous exertion of this force are, that the room shall be warmer than the external air, and that there shall be free access of fresh air to such room.

When the fire is lighted, the air, passing through the burning embers, is heated and expands. Consequently it rises, and so passes up the chimney, if all is well at the other end (i.e. if there is no "blow-down"). If there *is* a "blow-down," the air comes back into the room, carrying with it smoke and often sparks.

2. The *vis a fronte*.—The wind blowing horizontally over the tops of chimneys causes a current, at right angles to its path, up the chimney; the wind may, however, owing to "refraction," or to its own pressure, or by blowing down the chimney, counteract the normal tendency.

With regard to the various angles at which the wind exerts advantageous—or the reverse—results, the following may be cited:—

"The worst position for a flue is, as might be expected, near a dead wall, because the wind blowing against the wall causes momentarily a sudden pressure, which stops the escape of gases up the flue. A current impinging on the top of a flue in a downward direction, at an angle of 30° or upwards, checks the draught. A current across the top of the flue forming a less angle with the horizon than 30° increases the draught, and the most advantageous effect is produced when

the current strikes upwards at an angle of 30°" ("Lord Rayleigh's Cav. Lab. Tests, Cambridge").

Now that we have seen what are the chief forces upon which we have to rely for the up-draught in the chimney, I think it will be admitted that any circumstance, or combination of circumstances, which nullifies such forces, must tend to materially interfere with our up-draught.

I propose to consider the results of such circumstances under the following heads:—

1. Chimneys which smoke from defects arising from below, "*vis a tergo* defects."

2. Chimneys which smoke from some form of "blow down," "*vis a fronte* defects."

3. Chimneys which smoke from faulty construction.

1. CHIMNEYS SMOKING FROM *VIS A TERGO* DEFECTS.

(*a*) NOT SUFFICIENT SUPPLY OF FRESH AIR TO THE ROOM.

Test by opening the window of the room, *not door*, as there may be a "suction" to some other fire in the house.

Remedy, some form of air inlet.

(*b*) SUCTION DOWN ONE CHIMNEY, USUALLY A SHORTER ONE, TO SUPPLY SOME OTHER FIRE PROVIDED WITH LONGER CHIMNEY.

Remedy latter as above (*a*), and lengthen first chimney, if possible.

It has been recommended to use a special inlet for air right in front of the hearth.[1] I cannot commend this; the most suitable position for the inlet must be determined by the natural currents in the room.

To ascertain these, use some heavy smoke, which will be distributed about the apartment according as the natural currents "set."

[1] If air is admitted through an opening in the hearth, it mus reach that opening warmed, by passing over some heated surface, such as the back or sides of the grate itself.

2. CHIMNEYS SMOKING FROM *VIS-A-FRONTE* DEFECTS.

(*a*) Top of Chimney below a pitched Roof or the Eaves of the House.

Remedy, raise chimney, if practicable; or, if certain that this is the only defect, use some rotating cowl, or one

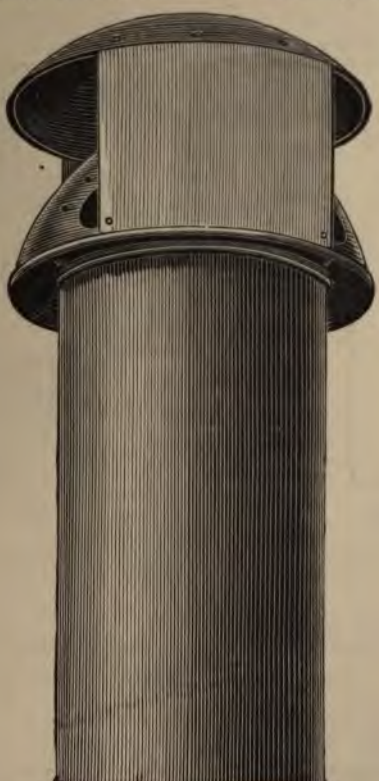


Fig. 34.

with baffle plates (fig. 34), plates being *parallel to* supposed obstruction.

(*b*) Chimney situated under high Wall or similar Obstruction.

Remedy, raise chimney, or use some such cowls as figs. 34 or 35.

In all similar cases the cause of smoke is "rebound" or "back pressure," and these cases I have found the most

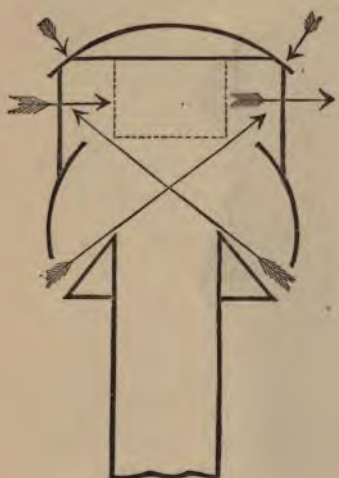


Fig. 35.

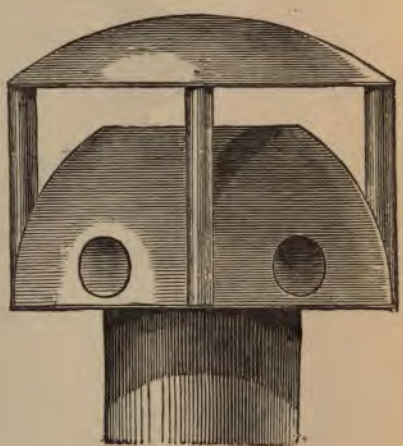


Fig. 36.

obstinate; occasionally I have found a cowl similar to fig. 35 very useful.

(*c*) Chimneys smoking from being exposed to Fury of Gales.

In such cases I have found cowl fig. 36 often a very successful cure.

The upward curves directing the wind at an angle of 30°, thus obtaining the greatest extracting force; whilst the downward curves of the "cap" of the instrument prevent direct wind-pressure on the mouth of the cowl.

3. CHIMNEYS SMOKING ON ACCOUNT OF FAULTY CONSTRUCTION.

These cases are, I think, difficult for amateurs to deal with, owing to inability to diagnose the case properly.

Perhaps the following may assist my readers :—

(*a*) FIRE-PLACE TOO OPEN.

This fault may be suspected if, on lighting the fire in such a grate (old-fashioned hobbed grate, high mantel-piece, &c.), the descent of the cold air above the hobs to the hottest point causes the smoke to puff out at once. This should indicate pretty clearly that the opening into the chimney (i.e. above the fire) is too large.

In conjunction with this, the following facts demand a place in the tablets of our memories :—If the proximal end of a chimney-flue be narrowed, the amount of air and smoke escaping through it will, of course, be diminished, though the velocity may be increased.

If the distal end of a flue be narrowed, the heated air and smoke will be ejected with greater force into the surrounding medium, often with an increased velocity sufficient to prevent a "blow-down;" one or two cases have come under the author's notice where such a narrowing has been the means of curing a chimney smoking.

To this there is, however, as to all good things, a limit; the chimney-top should never be narrowed down to an area less than $\frac{3}{5}$ the area of the flue.

Moreover, it should be borne in mind that every constriction in the area of a flue diminishes considerably the "ventilation" of the apartment to which such chimney belongs.

(*b*) CHIMNEY TOO SHORT.

Often a current may be traced from a short chimney (e.g. an attic) down to some other room, whose grate is provided with a longer flue; this is, indeed, the foundation of "the syphon theory," which sets forth, that, "given combustion, in an enclosed space, with which two tubes are connected, the

current will (*cæteris paribus*) descend the shorter tube, and ascend the longer."

Remedy, contract the short chimney, or lengthen it, and supply the other room (whither you have traced the current) with fresh air.

A cowl is no good here, except a long one—a "tall boy."

(*c*) One Chimney doing Duty for two Rooms.

This is a frequent cause of smoky chimneys.

Remedy, note the amount of air *passable and passing* up each flue (before they are amalgamated), contrast those figures with amount *passable and passing* out at chimney-top, and regulate accordingly.

Suppose there are two flues, in which the up-currents are respectively x and y, and x is greater than y, then if these two flues join a common duct at right angles, the one having the greater velocity, "x," will diminish that of the less, "y," by the amount of the excess of one once the other; or,

x being greater than y by, say, z,

then the result will be that y will become $y - z$.

If x and y are equal, no change of velocity will take place in either.

Again, if a short, almost horizontal flue be connected with a vertical flue, the current passing from the horizontal flue materially checks that in the vertical flue; indeed, if the rapidity of the current in the shorter flue is very much greater than that in the vertical, it may bring the latter current to a stand-still.

Such a short flue should never be led into a vertical one at (or anywhere near) a right angle, and should be provided with a "baffler," to direct the current vertically.

The vertical flue should not be less than twice the length of the tributary duct.

(*d*) Chimneys with sluggish Up-draught.

This is essentially the case for the use of some good cowl.

I should recommend fig. 37 as procuring the maximum

extracting power of the wind, viz. an upward current of an angle of 30°.

(*e*) BRICK CHIMNEYS BUILT ON EXTERNAL WALLS.

There is often a down-draught in such chimneys, owing to the wind, especially during gales, blowing through the bricks. It may be interesting to my readers to know that certain substances permit of diffusion of gases, especially under pressure, through them. The following is a quotation from Captain Douglas Galton's "Warming and Ventilation:"—

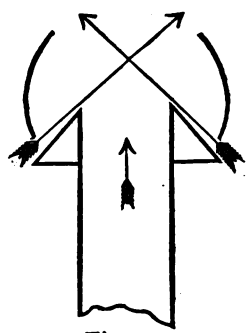


Fig. 37.

"The following table shows the volume in cubic feet, per hour, of air which passed through a square yard of surface of equal thickness of the following materials, the pressure being obtained by a difference in temperature of 72° Fahr. inside, and 40° Fahr. outside:—

	Cubic ft.
"Sandstone	4·7
Quarried limestone	6·5
Brick	7·9
Limestone	10·1
Mud	14·4"

Now the difference in temperature between the external atmosphere and the interior of a chimney-flue is probably more than 32° Fahr., and, above that, we have to take into account the velocity and pressure of the wind.

Here we have, I think, an easy explanation why brick chimneys exposed to gales smoke so frequently.

The best remedy I can suggest is to sink a galvanized iron tube down from the top of the chimney to just above the grate, or to coat the brick chimney outside with Ransome's damp-proof solution.

I have now brought my pleasant task to an end. Throughout this little work I have endeavoured to avoid all technicalities

and needless reference to scientific formula and so forth. My object has been simply to put the British householder in possession of plain facts concerning a science which has been ably described as the "application of the laws of physics and "physiology to the maintenance of the health and welfare of "individuals and communities." I am quite aware that I have given my readers the merest sketch of the matters which I have endeavoured to elucidate, but I have had to overcome the difficulty of condensing into a small space, and expressing in popular language, subjects upon which so much has been written, and about which so much is thought. If I have in any way instructed any of my readers or led them to inquire more closely into these vital questions, I am more than content.

FINIS.

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Experience has proved beyond a doubt

That the "Vowel" Washing Machine is the most practical and generally useful;

Is absolutely the best washer, because it operates simultaneously upon every part of the fabric, and cleanses efficiently in from five to ten minutes, according to the nature of the fabric;

The most economical in the use of soap and water;

The most economical in the wear and tear of linen;

The most desirable for "firsting" and "seconding;"

The most convenient for rinsing and wringing;

The most substantial and durable, and consequently the most permanently satisfactory.

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In thus setting forth the unmistakeable value of the "Vowel" Machine, we do not wish to speak or write disparagingly of any other kind, but we do feel it to some extent our duty to caution intending purchasers against misleading statements and advertisements, so freely published, that would lead the reader to believe that some machines will get through a family wash entirely without assistance, not only without rubbing, but without boiling—nothing is said, however, about the infinite amount of time and trouble necessary to prepare the linen, by steeping, soap-rubbing, &c., for such machines, which would, as a matter of fact, without this tedious preparation, be practically valueless. The statement that any machine will dispense with boiling must be taken with a *very* large grain of salt, as every practical laundress knows that neither the purity nor the colour of body linen can be maintained without boiling.

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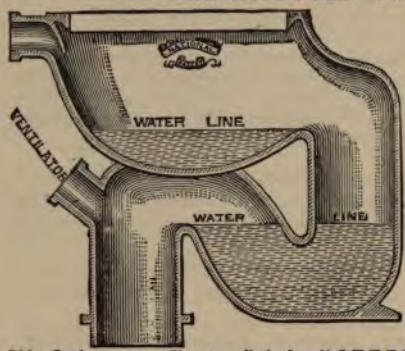

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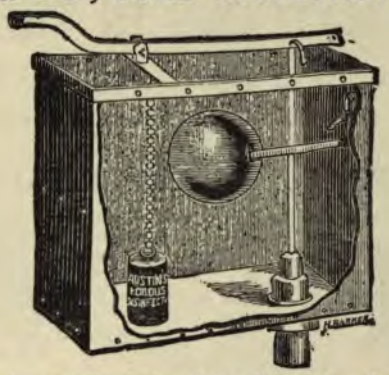

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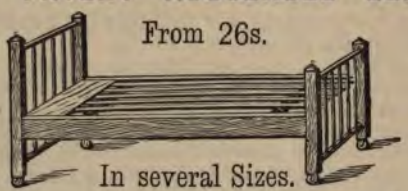

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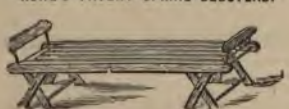

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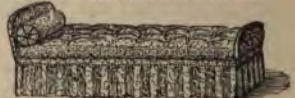

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